Three essays on firm dynamics with presence of financial constraints and macroeconomic shocks

Qiwei Wang

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Présentée par

Qiwei WANG

Thèse dirigée par **Patrick MUSSO**
codirigée par **Rachel BOCQUET**

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devant le jury composé de :

M. Patrick MUSSO
Professeur des Universités, Université de Nice Sophia Antipolis, Directeur de thèse
Mme. Rachel BOCQUET
Professeur des Universités, Université de Savoie, Co-directrice de thèse
Mme. Flora BELLONE
Professeur des Universités, Université de Nice Sophia Antipolis, Rapporteur
M. Olivier BROSSARD
Professeur des Universités, Institut d'Etudes Politiques de Toulouse, Rapporteur

Université Joseph Fourier / Université Pierre Mendès France /
Université Stendhal / Université de Savoie / Grenoble INP

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Introduction

In 1930, while the world economy crumbled in the great recession, John Maynard Keynes wrote in his essay entitled "The Great Slump of 1930", that "... we have involved ourselves in a colossal muddle, having blundered in the control of a delicate machine, the working of which we do not understand. The result is that our possibilities of wealth may run to waste for a time - perhaps for a long time." Since then, eighty-three years have passed, but his argument still fits the current recession that occurred after the bankruptcy of Lehman Brothers: five years after the crisis, the world economy is nevertheless struggling to get back on normal growth path. Notwithstanding that a large number of studies have been achieved since the 1930s, yet a lot remains to be done in understanding how our economy works with a financial environment abounding with more and more upheavals.

Arisen from the bust of bubbles in real estate and credit derivatives, the financial crisis in 2008 has rapidly transmitted contraction from financial sector to real economy, and finally induced a global recession. The crisis transmission has been operated partly through deterioration of firms' financing conditions, such as rise in cost of capital due to spurt of credit spread, and scarcity of financing resources owing to increasing credit rationing.

This contagion across sectors demonstrates the deep influence of credit market imperfections on the economy by disturbing its functioning at firm level, which reveals questions relative to firm dynamics. Furthermore, by analyzing firm dynamics at industrial level, which consists in firms' entry, growth, survival and exit, the effects of financial contraction on real economy also unveil issues related to market efficiency. In other words, the observations on the development of the last financial crisis and recession give rise to the question about the impact of financial imperfections on firm dynamics and market efficiency.

This thesis contributes to the literature on firm dynamics and market efficiency by showing plausible failure of market selection mechanisms due to presence of financial constraints and deteriorating macroeconomic conditions, which may also lead to distortion of market structure in terms of firms' Research and Development (R&D) investment patterns and intensified disparity between firms in terms of opportunity to benefit from economic stimulus.

0.1 General theme

Efficient market is one of the most important conceptions of modern economics. By definition, a market is considered to achieve efficiency when the resources allocation maximizes the total surplus received by all members of the market. The allocative efficiency refers to the fact that resources are allocated according to the productivity level of firms in the market.

Obviously, the notion of market efficiency implies the major assumption about perfect competition. When a market is perfectly competitive, productivity is the unique criterion of selection, which means only the most productive firms can survive; other firms with lower productivity should leave. To put it another way, perfect competition indicates that market selection mechanisms function well.

Beyond the static efficiency which corresponds to the maximization of total surplus, a stream of research (see e.g. Jovanovic (1982), Hopenhayn (1992)) studies dynamic efficiency by focusing on firm dynamics within the context of market selection. Following this direction, more and more studies try to analyze the problem of market competition in presence of various imperfections. For example, Bisin and Gottardi (1999) study competitive equilibria by focusing on questions about asymmetric information.

As revealed by the subprime crisis, financial imperfections may equally constitute those elements that could interfere with market selection. Numerous studies demonstrate the credible effects of financial frictions on firm dynamics. Bernanke et al. (1999) emphasize the influence of firms' financial situation on their investment and production. Holmstrom and Tirole (1997) stress the impact of the strength of financial intermediaries' balance sheet on firms' activity. In fact, both the issues relative to firms' balance sheet and financial intermediaries' financial robustness bring to the question about financial constraints, by means of the difficulties firms face in accessing external financing resources.

Accordingly, to what extent do market selection mechanisms work in presence of financial constraints? A large number of empirical studies exist with respect to this subject. Most research confirms that the market selection mechanism works with different degrees of efficiency (see e.g. Bellone et al. (2006)). However, we still know little about the functioning of market selection process under fluctuating macroeconomic conditions.

The recession struck in 2009 with simultaneously intensified financial restrictions displayed a profound influence on firms. It is evident that changes in macroeconomic environment also play a role in the effects of financial constraints on firms. This relationship involves at the same time two factors. One comes from macroeconomic domain, and the other microeconomic field. Whereas so far few studies are conducted with regard to firm dynamics under the impact of both factors.

The functioning of market selection process in presence of financial imperfections and macroe-

conomic fluctuations presents an insight into the structural effects of short-term variations in macroeconomic conditions on market efficiency. This viewpoint is relatively innovative compared to traditional literature which mainly studies the impact of changes in market structure on macroeconomic fluctuations (see e.g. Etro and Colciago (2010)).

However, beyond the analysis of effects of short-run macroeconomic variations on market structure, it is also necessary to study the long-run effects that the impact on market structure could have on economic growth. As it is widely accepted that R&D activities and innovation are one of the key drivers of economic growth in the long term, incorporating elements of R&D activities in the study on market selection process allows us to have a long-run perspective on firm dynamics and economic growth. In previous literature, a large body of research considers firms' R&D investment and innovation as major determinant of economic growth. For instance, Dosi et al. (2010) underline the importance of Schumpeterian engine - the endogenous innovation at firm level - to long-run economic growth.

The situation of economic downturn is mostly followed by government intervention resulting in stimulus policies. Such policies, mainly consist in increase in government spending, represent another form of changes in macroeconomic conditions within a stringent context. Abundant studies, generally from macroeconomic point of view, analyzed the transmission mechanism and outcome of government spending stimulation. Among them, questions relative to the value of fiscal multiplier have been put in an important position. However, this specific combination of determinants - financial constraints, declining economic environment and surge of global demand - has rarely been studied from the angle of firm dynamics.

This thesis aims at studying the impact of financial constraints and macroeconomic fluctuations on firm dynamics, and what it could unveil in terms of market selection mechanism, firms' R&D investment patterns and outcome of economic stimulus policy.

For the sake of clarity, let us introduce the definitions of the two principal determinants to the general theme of this thesis. In preceding literature, there exist various definitions of financial constraints. For instance, Kaplan and Zingales (1997) consider that financial constraints could be identified as the wedge between costs of internal and external financing sources. Silva and Carreira (2012) characterize the existence of financial constraints by the presence of credit rationing. Delli Gatti et al. (2009) argue that financial constraints are represented by variable interest rates which depend on firms' financial robustness. Based on the definitions from existing studies, the financial constraints in this thesis are defined as firms' restrictions on their access to lending from external financial intermediaries, which are expressed in the modeling by both varying interest rates contingent on firms' financial strength and potential credit rationing in the case firms become insolvent.

As the studies in this thesis consider short-term changes in macroeconomic conditions as the

second determinant of functioning of market selection mechanisms, it is preferable to focus on the variable of global demand as representative element which can clearly typify the influence of macroeconomic environment on firm dynamics.

0.2 Research questions

After the general theme, in this section let us present the three research questions which lead to the three chapters in this thesis.

Question one

Several studies analyze the functioning of market selection mechanisms under stringent macroeconomic conditions. In their theoretical work, Caballero and Hammour (1994) stress the "cleansing effect" by which the process of market selection is reinforced during recession, where firms with lower productivity are forced to exit from market, and those with higher productive efficiency stay in the industry. Consequently, strict economic conditions have positive effects on market selection mechanisms.

However, there exist counter examples. The empirical study of Nishimura et al. (2005) comes to an opposite conclusion. Based on Japanese firm data, they find that the natural selection mechanism did not work as expected during the downturn from 1996 to 1997. The failure of the selection process is considered as the main explanatory factor to the decrease of aggregate productivity after 1996.

The contradiction between the conclusions of these two studies exposes the debate on the effects of deteriorating macroeconomic environment on functioning of market selection process. Even though based on prior research evidence one can confirm the efficiency of market selection mechanism in presence of financial imperfections, the argument can only be validated under normal economic conditions. So far there is no clear statement on the subject in the case economic environment is contracting. Accordingly, my first research question is as follows: What are the effects of financial constraints on market selection mechanisms under aggravating macroeconomic conditions?

Question two

Another strand of literature focuses on the relationship between financial constraints and firms' R&D investment. Among them, a large number of empirical works study the impact of financial

constraints on firms' R&D activities. Hyytinen and Toivanen (2005) analyze Finnish SME data and find that capital market imperfections impede firm innovation and growth. With similar objective, studies based on firm data of various countries, such as Canepa and Stoneman (2008) for UK, Savignac (2008) for France and Mohnen et al. (2008) for Netherlands come to the conclusion that the impact of financial constraints is mostly important for small firms and high tech sectors. In addition, the financial barriers to innovation is represented by both cost and availability of financing resources.

Other theoretical studies try to understand why firms' R&D investment could be restricted. Hyytinen and Toivanen (2005) introduce a theoretical foundation to explain the impact of capital market imperfection on firms R&D activities and their growth. They demonstrate that imperfections of capital market induce both an increasing function of marginal cost of capital and a decreasing function of marginal rate of return on R&D investment and expansion. The upward slope of marginal cost of capital along R&D investment indicates that firms – in particular those with limited size – are more restrained in their investment in R&D activities if they are more dependent on external financial resources.

Hall (2002) suggests that comparing to other firms, small firms' marginal cost of capital has a steeper slope for a given value of R&D investment, because of the uncertainty in outcome of R&D activities and consequently future return on investment. Moreover, in contrast with investment in physical capital, investment in R&D is more financially constrained since it can hardly be used as collateral and is considered to carry high risk, given the uncertainty of its return and the problems of information asymmetry linked to it.

Several studies trying to explain why R&D investment could be financially trammeled emphasize peculiarities of R&D activities. Holmstrom (1989) stresses the question of moral hazard arisen from possible agency problems and cost of contract, which may lead to higher marginal cost for small firms. Aghion and Tirole (1994) underline the high uncertainty to have successful innovation. Anton and Yao (1994) and Bhattacharya and Chiesa (1995) highlight the problem of appropriation and the confidential nature of certain R&D projects as explications to high capital cost that small firms have to endure.

As a result, the pressure of financial restrictions on R&D investment pushes firms to seek recourse to internal funds instead of external financial intermediaries. Hall (2002) argues that firms with high R&D investment intensity resort in low proportion of financing by debt. Brown et al. (2012) claim that firms keep cash reserves in order to smooth volatility of R&D spending against finance shocks in short term. Other studies, such as Acharya et al. (2007), Almeida et al. (2004) and Kim et al. (1998) share the same standpoint.

It is noticeable that the peculiarities of R&D activities, especially the uncertainty of outcome and the problems related to asymmetric information bring about the fact that firms' R&D invest-

ment suffers financial restrictions, which compel firms to mainly use internal funds as financing resources. Consequently, investment in physical capital becomes more dependent on external resources when firms engage substantial R&D expenses, which makes them more vulnerable to financial constraints.

Moreover, the increasingly severe financing conditions during the recent recession demonstrate the impact that macroeconomic fluctuations could have on firms through both demand contraction and scarce financing resources. Firms investing massively in R&D activities may suffer more this impact due to their dependence on external financial resources. Taking into account this fact, my second research question is: Given the heterogeneity of firms in terms of innovation intensity, what could be the effects of financial constraints combined with declining macroeconomic environment on firms' survival likelihood?

Question three

Intended to evaluate the effects of economic stimulus policy, in particular a rise in government spending, an important number of research works attempt to estimate the value of multiplier, which measures the ratio of a change in output due to an increase in demand. The transmission mechanism from increase in global demand to output growth may work through stimulating both consumption and investment.

However, the presence of financial constraints could alter these effects by its influence on firms' capacity to invest. By contrasting two scenarios of simulation, one with financial frictions and the other without, Carrillo and Poilly (2013) demonstrate that financial restrictions reinforce the effects of increase in government spending on output. The amplification of multiplier effect is due to a capital accumulation mechanism, which refers to the process in which an increase in investment stem from supplementary demand leads to capital expansion and improvement of solvency. Firms' bettered financial strength in turn allows them to engage more investment and finally increase aggregate output.

At the same time, several theoretical studies with modeling of frictionless economic environment, such as Aiyagari et al. (1992), Baxter and King (1993), Ramey and Shapiro (1998), Burnside et al. (2004), Ramey (2011) and Gali et al. (2007), find the value of multiplier below one. Hence, from the opposite side, this result confirms the amplification effect that financial constraints might have on outcome of economic stimulation.

As another explanatory factor, business cycle is also proved to have influence on the scale of fiscal multiplier. Canzoneri et al. (2012) develop a new Keynesian model initialized by Curdia and Woodford (2009). With the model including financial frictions between lenders and borrowers, they suggest that the presupposed counter-cyclical financial frictions make spending multiplier

large during recession and modest during expansion. Such uneven effects are arisen from the mechanism in which an increase in output under economic downturn could curtail the pressure of financial frictions and boost borrowers' consumption. In succession, increased consumption and reduced financing costs allow economy to recover at a higher pace than in the background of economic expansion.

Altogether, both financial constraints and business cycle have important influence on the response of economy to stimulation policies. Nonetheless, the existence of financial restrictions induces a disparity in terms of financing conditions across firms. If firms may benefit from an increase in global demand by raising their investment, it is unclear whether it is done equally. Till today, this subject is still rarely studied. Therefore, my third research question is: In presence of both financial constraints and business cycle, what could be the differentiated impact of an macroeconomic stimulus on firm dynamics?

0.3 Research method

In order to answer the three questions above, I perform three theoretical studies with modeling and simulation. This choice is driven by the advantages and the relevance of the method vis-à-vis the research theme. The compounding of modeling and simulation provides the possibility to study the impact of specific factors on firm dynamics by introducing different scenarios in simulations.

This thesis follows the stream of evolutionary economics. As mentioned above, the center of the thesis rests on questions about functioning of market selection mechanism. In order to validate whether the mechanism works well, it is necessary to distinguish firms according to their individual productivity level. Meanwhile, one of the key determinants in the thesis - the presence of financial constraints - implicates the existence of a difference with regard to firms' financial strength and financing conditions.

This particularity of double differentiation requires a modeling method which can take into account the heterogeneity across firms in terms of productivity and financial situation. In consequence, the method of Agent-Based Models (ABMs) seems to be the most fitted to the theme of the research.

Since the last financial crisis, standard models - used by mainstream economists - are at the center of critiques. One of the principal targets of reproach is the representative agent hypothesis that is largely applied within those models. This hypothesis assumes that all agents in the economy are identical regarding their preference and features. Critiques are also focused on another assumption regularly used in standard models, namely the rational expectations hypothesis. This hypothesis presumes that agents have the knowledge of all models in the economy and integrate perfectly all information in their decision making.

On the other side, compared to standard models, ABMs consider economic process as a collection of heterogeneous agents with interactions between them, and the periodic interactions between agents lead to constantly varying patterns at microeconomic level. This modeling method with multi-agent presents several advantages (see Gaffard and Napoletano (2012) for a review). One of the main characteristics of ABMs is the incorporation of agents' heterogeneity. This important advantage gives the opportunity to study the evolution of agents with constantly varying features which are indispensable for the subject of research.

Moreover, on the contrary to classic models, agents in ABMs do not embrace equations of whole economic system and totality of information in their decisions making process. As a result, in place of calculating inter-temporal maximization in standard models, those agents' decisions are made by following predefined rules (see e.g. Fagiolo and Roventini (2012)). This characteristic of ABMs allows to analyze the reactions of agents to changes of different factors according to respective scenarios.

Another advantage of ABMs is that these models do not require that interactions between agents are fixed within equilibrium which implies that all markets in the built economic system must be cleared. This feature fits the fact that equilibrium cannot be permanent in all markets. This difference between ABMs and standard models provides the possibility to study various questions in presence of economic disequilibrium.

Additionally, ABMs propose other advantages in terms of modeling flexibility. For example, ABMs allow interactions between agents realized through diverse variables, in contrast to standard models in which price is mostly the only possible element that allows to reach equilibrium. Also being different from classic models, interactions in ABMs could be operated through decentralized network, which gives the opportunity to analyze dynamics of complex economic system (see e.g. Delli Gatti et al. (2009)).

0.4 Thesis plan

The thesis is composed of three chapters. All the three are based on the same theoretical fundament and develop from one modeling basis which entails computational simulation. Within the basic models, firms produce a homogeneous product through a Leontief type technology and by means of capital and labor. The competition between firms is realized based on price. The heterogeneity of firms is mainly represented by their productivity level, and in consequence their production decisions and financial conditions. Financially fragile firms have to undergo higher cost of capital and possibly credit rationing. Predefined exogenous shocks as changes of global demand intervene during the simulation. In each period, new firms being attracted by the profitable perspectives enter into the market. Meanwhile, firms failing the competition exit.

Based on the shared foundation of modeling and simulation, the three chapters study different subjects by analyzing the same explanatory factors, which consist of presence of financial constraints and fluctuations of macroeconomic conditions.

Chapter one

Attempting to answer the first research question, the first chapter is considered as central to the thesis. It provides the basis of model and simulation, which will be the benchmark to all the three studies in the thesis. The simulation results show that in presence of macroeconomic fluctuations and financial constraints, the pressure stem from market competition could lead to an inefficient market selection process, where longstanding incumbent firms with robust financial situation but relatively low productivity could survive, however, young and small firms with poor financial conditions have to exit from the market, even though they are more efficient.

The reason to such dysfunction of market selection mechanism could be in the first instance the mutual reinforcement between financial constraints and deteriorating macroeconomic conditions. On the one side, the presence of financial constraints leads to differentiated financing conditions across firms. The contractions of macroeconomic factors weaken firms' financial situation and aggravate the disparity between firms regarding their financing capacity. Consequently, macroeconomic fluctuations exacerbate the impact of financial restrictions on firms.

On the other side, when firms' financial strength get largely reduced during economic downturn, the existence of financial restrictions raises the cost of capital of firms in distressed situation, or even imposes on them credit rationing. Such increasing cost of capital aggravates those firms' loss and diminishes their chance to survive. Hence, financial constraints act as an accelerator by worsening the effects of declining macroeconomic conditions on firms and speeding up the exit of the most vulnerable ones.

The mutually intensified effects of these two determinants combined together could result in more detrimental consequences regarding firms, especially those traditionally suffer more from financial constraints, namely young and small firms. Therefore, the combination of these two determinants, one at macroeconomic level, the other comes from microeconomic sphere, strengthens their respective repercussions on economy by impacting on structure of market competition. The occurrence of macroeconomic deterioration aggravates the influence of financial imperfections on firms, which in turn worsens macroeconomic decline by impacting on firms' investment and survival, and furthermore, employment and consumption.

Moreover, the failure of market selection process could also be explained by another more profound reason which consists in the discrepancy between the competitions in market of product and market of credit. Within an ideal condition of perfectly efficient market, the competition

in product market is uniquely based on firms' productivity, and in credit market firms' financial strength. Under normal economic conditions, the two criteria are perfectly correlated, which means firms with higher productivity also have better financial performance and situation of balance sheet.

However, for a firm a delay could exist between the immediate improvement in profitability due to a rise in productive efficiency and the reinforcement of financial robustness, given the fact that for a firm with relatively small size, a short-run positive profit cannot radically change its state of solvency. In the contrary, it is necessary to have a certain number of successive periods with positive profit to reinforce the firm's equity and as a result its solvency. This harsh situation may happen especially when stringent financial constraints and deteriorating economic conditions strike at the very same time. Yet in reality these two factors often arrive jointly.

Conditioned by the specific circumstances, certain firms with poor financial robustness and limited size see their financing conditions remain severe, in spite of improved net incomes. Therefore, some of them may go bankrupt before the pressure of financial constraints get significantly alleviated, despite their high productivity. Thus the presence of financial constraints and rigorous macroeconomic conditions may enlarge the gap between the competitions in the two markets, which finally induces the occurrence of inefficient market selection.

This chapter contributes to the literature on firm dynamics. The dysfunction of market selection mechanism in presence of both financial constraints and shock of global demand demonstrates a plausible failure of efficient market, under the impact of financial imperfections and deteriorating macroeconomic environment. Meanwhile, the results of this study challenge the arguments of "cleansing effects". On the contrary to what is claimed, under specific conditions the functioning of market selection may be impeded during economic recession.

Chapter two

The second chapter responds to the second research question. Employing the same modeling basis, in the models of this chapter, the dynamics of productivity and expenses in R&D are considered as endogenous elements. The simulation results show that under influence of financial constraints and stringent macroeconomic conditions, there could be a market structure distortion in terms of R&D investment patterns, where firms willing to engage proportionally substantial R&D investment, in particular those investing massively in explorative research projects, are eliminated with high percentage. However, other firms inclining to invest more in physical capital survive the economic downturn thanks to their more robust balance sheet.

This distortion of market structure is driven jointly by the uncertainty of return on R&D investment and the combination of financial constraints and declining macroeconomic conditions.

In the models of this chapter, each firm has to make its periodic investment decision between physical capital and R&D activities, and investment in R&D can only be financed by internal funds. Moreover, within its R&D investment, each firm makes its decision between safe and risky R&D projects. As a consequence, according to their proportion of investment in physical capital, firms are characterized as pro-capital or pro-R&D. Based on their percentage of investment in safe R&D projects, firms are classified as pro-safe or pro-risky R&D profiles.

As studied by previous research, one of the main peculiarities of R&D investment is the uncertainty of its future return. In the context of the present study, the realized outcome of R&D investment engenders productivity improvement. Meantime, the uncertainty is a decreasing function of the amount invested in R&D activities.

The existence of uncertainty of return and the arbitrage between investment in physical capital and R&D activities lead to the relationship which indicates that the more a firm invests in R&D activities, the less it has to bear uncertainty about future productivity improvement, meanwhile the more dependent on external financing resources it becomes. Moreover, because the uncertainty of return on risky R&D projects is higher than safe R&D projects but with higher potential gain in productivity, firms preferring to engage more investment in risky field suffer more from uncertainty of return and fragile financial conditions.

In normal time, by increasing future profits, the potential gain of productivity of firms with high innovation intensity offsets their disadvantage relative to higher cost of capital due to less robust balance sheet. However, under rigorous and persistent macroeconomic conditions, firms' financial situation is weakened on the whole. The presence of financial restrictions worsens the financing conditions of firms with poor balance sheet by increasing interest rates and imposing credit rationing. Firms with pro-R&D investment pattern, especially those with pro-risky R&D investment intent represent the majority of exiting firms under high pressure of financial constraints because of their low equity level due to their intensive R&D investment.

The notion of uncertainty of return also implies the fact that higher uncertainty induces lower probability of realization of productivity gain in the short term. The compounding of difficult economic context and financial frictions together with uncertainty of return on R&D investment leads to elimination in large proportion of firms with high innovation intensity.

Considering the increasing relationship between R&D activities and productivity growth, the discouragement of R&D investment arisen from the distortion of market structure may also affect firms' productivity dynamics in the long term.

The contribution of this study consists in a new insight into firm survival likelihood from the angle of R&D investment, which indicates a plausible distortion of market selection process, in which firms with higher innovation intensity are largely disadvantaged under the influence of financial constraints and stringent macroeconomic conditions.

Chapter three

The third chapter answers the third research question. This essay analyzes the transmission mechanism from budget policy to firm dynamics performing through the channel of firms' investment and dynamics of productivity. The simulation results shed light on the existence of a significant effect of increase in global demand on firms' investment. However, the effect is altered by a distortion of market competition owing to presence of financial constraints and stringent economic context.

An economic stimulus is represented at firm level as abrupt spurt of global demand. This rapid increase in demand stimulates firms to enlarge their production by raising the quantity of productive factors, which involves a substantial investment in capital. The increased capital improves firms' financial situation, which in turn allows firms to invest more and reduce their cost of capital.

Nonetheless, firms are not equal within this wave of investment. Only those with high financial strength and hence less restrained – without risk of credit rationing and benefit lower interest rates – can fully enjoy the stimulus policy. The others can only invest with limitation because of their high debt ratio. This disparity in terms of financing conditions may persist due to the fact that firms suffering less pressure from financial constraints could reinforce their position in the market by improving their balance sheet and increasing their size. However, this process is more difficult to realize for firms financially bounded.

Furthermore, this inequality is intensified when the background of such economic stimulus is severe. Since firms' financial situation is generally weakened, the disparity of financing conditions across firms is aggravated. In consequence, with the arrival of increase in global demand, the imbalance of investment and expansion between firms is still amplified.

To conclude, it is clear that business cycle inflicts substantial influence on the outcome of macroeconomic stimulation: in contrast to what can be observed during expansions, stimulus policies in economic downturn have more differentiated effects on firm dynamics, thanks to the undermined financial situation of certain firms, particularly the young and small ones. The presence of financial constraints has double effects on outcome of macroeconomic stimulus. On the one hand, the existence of financial restrictions intensifies response of firms' investment facing an increase in global demand; on the other hand, it aggravates the disparity between firms regarding possibility of growth and survival.

This study contributes to the literature on firm dynamics by stressing the mixed effects of an economic stimulus on firms. More precisely, the intensified inequality between firms in terms of opportunity to benefit from an increase in global demand during economic downturn.

Chapter 1

Market selection, financial constraints and shock of demand

Abstract

In this paper we build a agent-based model, in which heterogeneous firms try to survive market competition by making decisions of production with the presence of financial constraints and fluctuations of macroeconomic conditions. Contrary to arguments of "cleansing effect", our simulation results demonstrate that with deteriorating macroeconomic conditions market selection mechanism may not function as expected by neoclassical economic theories. The fact that a delay could exist between improvement in profitability due to rise in productive efficiency and reinforcement of financial robustness, and the existence of financial constrains brings on a discrepancy between the selection in terms of productive efficiency and financial robustness, and leads to a distortion in bank loan market compared to product market: a firm's financing conditions depend directly on its financial solvency instead of its productivity level. Aggravating economic environment emphasizes the impact of financial frictions by worsening firms' solvency. Consequently, as important explanatory factors to the dysfunction of market selection mechanism, financial constraints combined with restrictive macroeconomic conditions could lead to negative effects regarding long-run aggregate productivity and output growth.

Keywords: firm dynamics; market selection mechanism; financial constraints.

1.1 Introduction

The worldwide financial crisis in 2008 and subsequent economic recession have triggered off harmful impacts on employment and bankruptcy waves, due to drop in global demand and restriction of financing conditions. However, the effects of crisis and recession do not stop at the level of bankruptcy and unemployment.

The influence of restrictive economic environment on firm dynamics also has an important relevance to fundamental theories. Neoclassical economists believe that a capitalist market economy could deviate from its equilibrium, but such disturbance would be temporary and the market mechanism would operate relatively quickly and efficiently to restore full employment equilibrium. If this economic analysis is correct, then government intervention, in the form of activist stabilization policies, would be neither necessary nor desirable. Even for one of actual mainstream economic thoughts – new classical equilibrium business cycle theory – the optimizing power of market forces is always incontestable. One of the essential features of this stream is the market efficiency, which represents at industry level the selection mechanism on firms' productivity by market force: in an economy based on efficient market, only the most productive firms can survive.

Market selection mechanism denotes the process of eliminating less productive firms through market competition. The dysfunction of market selection mechanism discloses a profound issue related to aggregate productivity and output growth. If firms with higher productive efficiency are obliged to exit from the market, aggregate productivity growth may not reach the expected level. Hence aggregate output could underperform its optimal state.

Multiple empirical works prove that in most cases and with different degrees of efficiency, the theoretical market selection process works, even in presence of financial constraints (see e.g. Bellone et al. (2006)). Nevertheless, one counterexample exists, Nishimura et al. (2005) point out, the failure of the mechanism in question causes the decrease of Japanese productivity in 1997. Therefore, what are the effects of financial constraints on market selection mechanisms under aggravating macroeconomic conditions?

In this paper, following evolutionary stream, we introduce an agent-based discrete dynamical

model, where heterogeneous firms try to survive market competition under impacts of fluctuating macroeconomic conditions. With distinct productivity level, firms produce a homogeneous product by means of capital stock and labor inputs. New firms enter into market contingent on the evolution of market profitability level. Incumbent firms failed in the competition or became insolvent have to exit from the industry. Determinants from both endogenous and exogenous environments influence firms' dynamics: on the one side, they are subjected to financial constraints, which is a function of their financial robustness; on the other side, analyzed in separate scenarios, macroeconomic conditions such as aggregate demand fluctuates and disturbs the competition between firms.

We carry out simulations within a scenario where shock of global demand intervenes accompanied by restriction of financing conditions. The results illustrate a plausible failure of market selection mechanism under impacts of distressed macroeconomic conditions. On the one hand, the existence of financial constraints results a discrepancy between the selection on productive efficiency and financial robustness and leads to a distortion in bank loan market in contrast to product market: a firm's financial costs are linked directly to its financial solvency instead of its productivity level. The occurrence of such discordance between two markets stem from the fact that a delay could exist between improvement in profitability due to rise in productive efficiency and reinforcement of financial robustness. On the other hand, aggravating economic environment emphasizes the impact of financial constraints by worsening firms' solvency situation. The joint effects of these two factors compel an increasing number of firms exit from market because of their financial fragility instead of their productivity, and there is no significant difference in terms of productivity between exiting firms and incumbents. Consequently, market selection process may not function, hence the growth of aggregate productivity could not reach its optimal level. Deterioration of macroeconomic conditions could modify the structure of market competition, which in turn impacts long-run aggregate productivity and output growth.

This paper contributes to economic theories related to firm dynamics and market efficiency. The dysfunction of market selection mechanism in the presence of both financial constraints and shock of global demand demonstrates a plausible failure of efficient market, under the impact of

financial imperfection and deteriorating economic environment. Meanwhile, the results of this study challenge the arguments of "cleansing effects" (see e.g. Caballero and Hammour (1994)), which claim that during economic downturn firms with poor productivity will be eliminated from market, hence economic recession reinforces the market selection process. Our simulation results clearly show the contrary: in economic downturn exitors could include firms with both lower and equal productivity compared to incumbents. The functioning of market selection may be impeded when the economy is in distressed state.

With regard to economic policies, if the natural selection mechanism does not work in expected way where competition is purely oriented by productive efficiency, especially in period of tough economic conditions, more government intervention should be encouraged, especially those targeting on easing firms' financing conditions, in order to assist and support firms - in particular those with young age or small and middle size - to go through crisis.

This paper is organized as follows. The next section gives a brief review of existing research related to our topic. Subsequently we introduce the modeling in section three. Section four presents simulation results, followed by conclusion at the end.

1.2 Literature review

1.2.1 Firm dynamics and financial constraints

Among different factors, financial constraints play a vital role in explaining firm dynamics - growth and survival - through impacting on firms' investment capacity. Both theoretical and empirical research works corroborate this standpoint. Fazzari et al. (1988) view financial constraints as an explanation for the dynamic behavior of aggregate investment. Evans and Jovanovic (1989) demonstrate that the liquidity constraints are essential in the decision to become an entrepreneur.

Clementi and Hopenhayn (2006) build a multi-period borrowing and lending relationship with asymmetric information. They argue that as a feature of optimal long term lending contract, borrowing constraints reduce with the increase of borrower's claim in future cash flow. They

also show a negative relationship between a firm's value and its exit hazard rate. Based on this research framework, Brusco and Ropero (2007) try to realize improvement by adding the concept of durable capital and a stochastic liquidation value into the initial model. The introduction of durable capital permits to take into account the size as a factor of firms' dynamics and investment decisions. The insertion of stochastic liquidation value allows to have a positive probability of liquidation under the first best. The results show that high stock of capital could reduce a firm's chance of bankruptcy, improve its future expansion and lower its volatility.

For the empirical side, numerous studies are achieved on this topic. Carpenter and Petersen (2002) estimate data of American small companies and point out significant effects of internal finance availability on asset growth. Furthermore, they also demonstrate a positive relationship between access to external financing and growth rate of firms. Aghion et al. (2007) use a firm-level database to assess the role of financial development on firm entry, the size at entry and post-entry performance of new firms. They suggest that the access to external financing resources is more important for the entry of small firms, and this factor could improve the market selection mechanism by permitting the competition between small firms and large firms on a more equal balance. They equally demonstrate that financial development could help improve firms' post-entry growth.

Based on French firms data, Musso and Schiavo (2008) use a composed and continuous measure of firm-level financial constraints to analyse the relationship between financial restrictions and firm dynamics. The estimate results show that financial constraints have a significant impact on the probability of firm survival, and access to external financing resources is propitious to ameliorate firms' growth. Gertler and Gilchrist (1994) illustrate that liquidity constraints may explain why small manufacturing firms respond more to a tightening of monetary policy than do larger manufacturing firms. Perez-Quiros and Timmermann (2001) show that in recession smaller firms are more sensitive to the worsening of credit market conditions, which is measured by higher interest rates and default premium. Angelini and Generale (2005) find in their dataset of Italian firms that young firms have more financing restraints.

1.2.2 Market selection mechanism and firm dynamics

Empirically there exist numerous studies trying to validate the efficiency of this market selection mechanism. Their results show that in general the selection process of firm works. For instance, Baily et al. (1992) and Haltiwanger (1997) employ a longitudinal dataset and found that firm-level entry and exit patterns have significant impact on the overall productivity growth of U.S. manufacturing industry. Griliches and Regev (1995) based on Israeli manufacturing firms data show that the effects of a firm's turnover on industry-level labour productivity were quite small. Bellone et al. (2006) study post-entry and pre-exit performance of French manufacturing firms for the period 1990-2002. The authors demonstrate that market selection process works properly across French firms, and market share reallocation across incumbents play a crucial role in improving productivity within French manufacturing firms.

However, in the theoretical area, two distinct schools of economic thought, neoclassic and evolutionary economics have different stances pertaining to the relationship between firm productivity level and its dynamics.

The central role of market in selection among heterogeneous firms is stressed in neoclassical microeconomic dynamic modelling where the heterogeneity at productivity level is incorporated into dynamic equilibrium framework. This approach begins with the research of Jovanovic (1982). The author establishes a model where the firm maximizes its expected discounted future cash flows, and makes its decisions of entry, continuation and exit based on the results of optimization. The firm dynamics is realized within following process: at the beginning firms are donated with a constant profitability parameter, which determines the distribution of their future profit stream. A new firm does not know its relative efficiency level, which is represented in its cost function, but discovers it through the process of Bayesian learning from its post-entry profit realization. As a result, young firms have higher failure probabilities and more volatile growth rates. The model equally allows to replicate industry dynamics patterns in which firm size distribution can be stable over time despite the introduction of fluctuation at firm level through entry rates, failure of entrants, or displacement of incumbents through the growth of successful entrants.

Evolutionists have another point of view relating to the topic. They emphasize more on the sources and processes of innovation which characterize firms' heterogeneity and then impact their dynamics. Silverberg et al. (1988) build a self-organization model based on a number of behavioural assumptions and a structure of feedback loops. The constructed system is characterized by the feature of a set of microeconomic diversity and disequilibrium. The simulation results demonstrate a distinct firm dynamics process: some firms could experience a short run loss but a long run gain in terms of market share, some other firms could lead into a vicious spiral towards bankruptcy.

1.2.3 Macroeconomic conditions

If the functioning of market selection mechanism is confirmed through both theoretical and empirical approach, its validation within the context of stringent economic conditions is still a debate in the research field.

Although there exist few research centered on this question, their results are totally contradictory. Caballero and Hammour (1994) establish a vintage model of creative destruction within a partial equilibrium. In their modeling a perfectly competitive industry experiences exogenous technical progress, and reveal the positive standpoint of cleansing effect of recession through the angle of employment. From the results of simulation, job destruction is more sensitive than creation to the business cycle, which means outdated or unprofitable techniques and products are pruned out of the productive system. Therefore the economic recession display a positive effect in which market selection mechanism works properly by cleaning firms with weak productive performance out of the industry.

Another empirical study draws completely opposite conclusions. Nishimura et al. (2005) use a Japanese firm-level panel database in order to study the relationship between firms' productivity level and their dynamics in terms of entry, survival and exit. They found that the natural selection mechanism did not work as expected during the recession of 1996 to 1997. Firms with higher productive efficiency exit from the market however inefficient ones stay. Such malfunction contributes

considerably to a decrease in aggregate productivity level after 1996.

The clear contradiction between the conclusions of these two studies reveals the debate on the effects of macroeconomic fluctuations on functioning of market selection mechanisms. Few research works are done on this topic, which gives us the possibility to fill the gap by realizing studies related to the subject.

1.3 Model

We establish an agent-based model in which firms are heterogeneous regarding productivity and financial conditions. In our modeling, the industry evolving in discreet time $t = 1, 2, ...$, firms in this industry are denoted by $i = 1, 2, ...$ By means of capital K_{it} and labor L_{it}, firms produce and sell a homogeneous product with different prices p_{it} in a competitive market. Each period firms make their decisions in terms of production and investment, taking into account their financial constraints and fluctuations of macroeconomic factors.

1.3.1 Sequence of events

1. Aggregate demand varies in value according to its own growth rate.

2. The market demand to each firm is a function of aggregate demand level and the firm's market share, which depends on the gap between it's price and the weighted average price level of the market in previous period.

3. At the beginning of each period, firms estimate their turnover by observing the market demand. Based on their marginal cost of current period, each firm determines its price and deduces its production volume.

4. To achieve the desired quantity of production, each firm has to fix its capital level (the case of disinvestment is excluded), and then the quantity of its labor. With the existence of financing constraints, certain firms - restricted from borrowing enough funds to reach their

desired assets level - have to produce less than their desired quantity. As a result, the demand of market will not be entirely satisfied.

5. In each period, if the industry remains relatively profitable compared to the cost of entry, new entrants are attracted to enter. A mechanism of market share reallocation between incumbents and new firms is introduced. Meanwhile, firms failing market competition quit the industry according to predefined criteria.

1.3.2 Production

Firms produce with constant returns to scale through a Leontief type technology. The production function is expressed as

$$Y_{it} = min\{K_{it}, \theta_{it} L_{it}\} \tag{1.1}$$

where Y_{it} is output, θ_{it} is labor productivity.

The total cost of each firm TC_{it} is then calculated by

$$TC_{it} = r_{it}(A_{it} + B_{it}) + \delta K_{it} + w_t L_{it} + F \tag{1.2}$$

where r_{it} represents interest rate, A_{it} and B_{it} signify respectively equity and debt value. For the sake of simplicity, we consider capital resources from shareholders and bank loan have the same level of cost, by supposing that firms distribute dividend to shareholders as remuneration at the same level as interest rates every period. δ designates productive capital depreciation rate, w_t is wage. The cost of labor is assumed as exogenous. F indicates fixed costs.

Assuming that there exists no restriction on labor supply, we can write

$$K^*_{it} = Y^*_{it}, L^*_{it} = \frac{Y^*_{it}}{\theta_{it}} \tag{1.3}$$

where Y^*_{it} represents the real production, K^*_{it} is the necessary quantity of capital used in pro-

duction. By excluding the possibility of disinvestment, in case of economic contraction, the rate of utilization of productive capacity could be lower than 100%, in other words, $K_{it}^* \leq K_{it}$. L_{it}^* corresponds to real quantity of the other productive factor.

Then the unit cost to a firm should be

$$UC_{it} = \frac{TC_{it}}{Y_{it}} \tag{1.4}$$

We consider a simplified balance sheet structure where firms finance their productive activities with equity and debt, ruling out the possibility of new equity issuance. By ignoring the possible existence of inventory, the current assets which consist of cash $\pi_{it} + \delta K_{it}$ constitute a firm's self-financing capacity. We also simplify the balance sheet by assuming that firms always prefer to reimburse their past borrowing when they have positive self-financing capacity. In other words, the current assets reduce debt. Therefore, a negative debt indicates a cumulative reserve of positive self-financing capacity.

$$B_{it} = B_{it-1} - (\pi_{it-1} + \delta K_{it-1}) \tag{1.5}$$

Accordingly, $K_{it} = A_{it} + B_{it}$. Based on this assumption, marginal cost MC_{it} could be expressed as

$$MC_{it} = r_{it} + \delta + \frac{w_t}{\theta_{it}} \tag{1.6}$$

1.3.3 Demand

We assume the value of aggregate demand evolves with exogenous growth rate g_t

$$D_t = (1 + g_t)D_{t-1} \tag{1.7}$$

Then market demand to each firm in quantity is

$$d_{it} = \frac{s_{it} D_t}{p_{it}} \tag{1.8}$$

where p_{it} indicates price and s_{it} is market share of each firm. The market share is calculated as a comparison between the price of the firm and the average price of the market in previous period. λ could be considered as price elasticity of demand, it measures the sensitivity of quantity demanded of a product to the change of its price relative to market average, and $\lambda > 0$. When $\lambda < 1$ the demand is less elastic which means the change of demand is slight compared to the change in price. When $\lambda > 1$ the demand is more responsive to any movement of price. With the expression

$$s_{it} = (\frac{s_{it-1}}{p_{it-1}})^{\lambda} / \sum_i (\frac{s_{it-1}}{p_{it-1}})^{\lambda} \tag{1.9}$$

We also introduce the market price index $\overline{P}_t$ calculated as weighted average price

$$\overline{P}_t = \frac{\sum_i p_{it} Q_{it}}{\sum_i Q_{it}} \tag{1.10}$$

where Q_{it} is the quantity sold, $Q_{it} = min\{Y_{it}, d_{it}\}$

The profit of each firm is consequently the difference between turnover and total cost

$$\pi_{it} = p_{it} Q_{it} - TC_{it} \tag{1.11}$$

1.3.4 Production decision

We assume that firms observe the market demand to each of them at the beginning of every period. By knowing the demand volume, a firm can determine its desired production quantity with $\hat{Y}_{it} = d_{it}$. Considering the costs of productive factors r_{it} and w_t, market demand d_{it} and productivity level θ_{it} as given.

In previous research works, the determination of price has various mechanisms. Price could be fixed at a constant value (see e.g. Clementi and Palazzo (2010)), or around market price (see

e.g. Napoletano et al. (2005)), or within a interval (see e.g. Assenza et al. (2007)), or with a fixed mark-up rate (see e.g. Dosi et al. (2010)). In our modeling, with the knowledge of their marginal cost level, firms fix their price by adding a markup to their marginal cost.

$$p^*_{it} = (1 + \mu_{it})MC_{it} \tag{1.12}$$

where the endogenous markup μ_{it} is assumed to be a function of the firm's market share of preceding period

$$\mu_{it} = \mu_0 + \alpha s^{\beta}_{it-1} \tag{1.13}$$

In this equation, the constant μ_0 represents the minimum markup level that a firm needs, α and β are two parameters to define the relationship between a firm's past market share and its markup level. This mechanism is in the same spirit as Dosi et al. (2010) but applied in a different way. In their modeling a firm's markup in period t is a function of its markup value in $t-1$ and its market share in two previous periods $t-1$ and $t-2$. It also corresponds indirectly to the statement of Campbell and Hopenhayn (2005), that the increase in number of competitors has a negative impact on firms' mark-up determination. More competitors means lower market share, which should decrease desired markup level.

Through these equations we can then determine the desired production volume and price

$$p^*_{it} = (1 + \mu_{it})(r_{it} + \delta + w_t/\theta_{it}) \tag{1.14}$$

$$\hat{Y_{it}} = \frac{s_{it}D_t}{(1 + \mu_{it})(r_{it} + \delta + w_t/\theta_{it})} \tag{1.15}$$

At the beginning of each period, when a firm has determined its price p^*_{it} and target output $\hat{Y_{it}}$, it defines also its desired quantity of capital $\hat{K_{it}}$ and labor $\hat{L_{it}}$, depending on the output and costs of productive factors. A firm can adjust its labor quantity at market wage rate without obstacle. However, if its accumulated capital is not enough comparing to the target level, it has to

seek recourse through external financial intermediaries, where comes up the question of financing constraints that we will discuss in section 1.3.7.

1.3.5 Equity, debt, assets and investment

By assuming that firms cannot raise capital via issuing new equity, the evolution of a firm's equity A_{it} is strictly related to its profit of past period

$$A_{it} = A_{it-1} + \pi_{it-1} \tag{1.16}$$

Following the traditional way, the dynamics of productive capital is defined by the rhythm of depreciation and value of investment I_{it}

$$K_{it} = (1-\delta)K_{it-1} + I_{it-1} \tag{1.17}$$

In case of increasing activities where desired capital stock is rising, an investment in productive assets is necessary.

$$\hat{I}_{it} = \begin{cases} \hat{K}_{it} - (1-\delta)K_{it-1} & \text{if } \hat{K}_{it} > (1-\delta)K_{it-1} \\ 0 & \text{otherwise} \end{cases} \tag{1.18}$$

Considering no possible new equity issue, productive capital has two financing resources: self-financing and lending from external financial intermediaries. According to the theories of pecking order, firms always prefer internal funds than bank borrowing as financing resources. In this context, we assume that firms always consider using their self-financing capacity in the first place. As a cumulative positive current assets, self-financing then could be described as follows:

$$\begin{cases} |B_{it-1}| & \text{if } B_{it-1} < 0 \\ 0 & \text{otherwise} \end{cases} \tag{1.19}$$

In case of insufficient self-financing capacity, firms have to resort to bank lending BL_{it}.

1.3.6 Productivity

We use a simple mechanism of shocks to drive the dynamics of firms' productivity. Based on its level in previous period, each firm receives a periodic shock of productivity, which is normally distributed. In the interest of carrying out the simulations with stability, it is important to maintain a relatively stationary state of aggregate productivity in order to analyze the impacts of financial constraints and fluctuations of macroeconomic conditions on firm dynamics. To reach this objective, we introduce a constant ϑ that attaches the dynamics of productivity jointly to its initial and periodic values.

$$\theta_{it} = \vartheta\theta_{it-1} + (1-\vartheta)\overline{\theta}_{i0} + \epsilon_{it} \tag{1.20}$$

where $\epsilon_{it} \sim N(0, \sigma_\epsilon^2)$, $0 \leq \vartheta \leq 1$

1.3.7 Financial constraints

Firms' debt B_{it} follows an one-period renewal motion, at the end of each period the debt is paid back and at the beginning of subsequent period a new debt B_{it+1} is engaged.

As we point out previously, financial constraints are one of the main determinants of firm dynamics. In our modeling, the constraints are expressed by varying interest rates that depend on firms' financial robustness and credit rationing that firms with high debt/assets ratio could be subjected to.

Inspired by Napoletano et al. (2005), we design interest rate as determined by risk-free rate r_f, average debt ratio $\overline{b_t}$ and the gap between a firm's debt ratio b_{it} and the lowest debt ratio in the industry b_t^{min}, where $b_{it} = \frac{B_{it}}{K_{it}}$.

$$r_{it} = r_f[1 + \rho f(\bar{b}_{t-1}) + \varrho(1-\rho)g(b_{it-1} - b_{t-1}^{min})] \tag{1.21}$$

where ρ fixes the proportion of two determinants of interest rate and $0 < \rho < 1$. ϱ is a credit spread coefficient, $\varrho > 0$. $f'(.) < 0$ and $g'(.) > 0$. From the expression, three elements determine

the interest rate of a firm. When its debt ratio is high comparing to the firm of best financial performance, or firms' financial condition is weakened as a whole, or the credit spread is enlarged, the interest rate of a firm raises accordingly.

In our modeling interest rate plays a central role in the influence of financial constraints. Like Delli Gatti et al. (2009), we can say that the firm's scale of production is financially constrained: it is delimited by its financial situation via the interest rate determination mechanism.

A firm's desired bank lending depends on the value of its desired investment and self-financing capacity. We could enumerate this relationship in the following expression:

$$\hat{BL}_{it} = \begin{cases} \hat{I}_{it} & \text{if } B_{it-1} \geq 0 \\ \hat{I}_{it} - |B_{it-1}| & \text{if } B_{it-1} < 0 \ \textit{and} \ |B_{it-1}| < \hat{I}_{it} \\ 0 & \text{if } B_{it-1} < 0 \ \textit{and} \ |B_{it-1}| \geq \hat{I}_{it} \end{cases} \tag{1.22}$$

Credit rationing constitutes another financing constraint to firms: if with the objective borrowing value BL^*_{it} a firm could have exceeded the limit on solvency, the credit will only be partly granted. This measure means that the financial intermediaries try to limit potential damage linked to default risk by restricting the debt ratio of its clients. As a consequence, knowing the combination of productive factors allowing to obtain an one-period lowest production cost, the firm has to reduce its output and correspondingly the quantity of other productive factors.

We introduce a threshold of maximum debt ratio b^{thr}_t as a limit according to which banks can finance a firm. The volume of bank lending could be restrained if the desired debt ratio goes beyond the limit. As a result, effective bank lending volume is determined in the following way:

$$BL_{it} = \begin{cases} \hat{BL}_{it} & \text{if } (\hat{BL}_{it} + B_{it-1})/\hat{K}_{it} < b^{thr}_t \\ b^{thr}_t \hat{K}_{it} - B_{it-1} & \text{otherwise} \end{cases} \tag{1.23}$$

1.3.8 Entry and exit

Several streams exist in the literature of firm dynamics with regard to entry process. For example, Winter et al. (2003) utilise a stochastic mechanism to determine new entrants. But in a

more traditional way, an endogenous process has been applied. Proposed by Jaimovich (2007) and Hopenhayn (1992), through an optimization calculation, the number of new entrants depends on industrial margin level, cost of entry of the industry and their individual productivity shock. Recent studies try to improve the pattern. Clementi and Palazzo (2010) give new entrants heterogeneous characteristics. Delli Gatti et al. (2003) introduce a mixed model where the number of entrants is an increasing function of the number of incumbent firms, the equity value of new entrants follows a normal distribution.

Based on the literature and stylized facts related to new entrants' profile, we model the number of entrants N_t^e is increasing in weighted average profit rate of the industry Π_t and decreasing in cost of entry c_e.

$$N_t^e = round[\chi_t] \tag{1.24}$$

with $\chi_t \sim N(\chi_t, \sigma_{\chi_t}^2)$, and the round function $f(x) = [x]$ guarantees an integer of entrant number. The value of χ_t is determined directly by weighted average of capital return rate and entry cost:

$$\chi_t = \frac{\Pi_{t-1}}{c_e}\Omega \tag{1.25}$$

In this expression, $\Pi_t = \frac{\sum_i \pi_{it} Q_{it}/K_{it}}{\sum_i Q_{it}}$, Ω is a parameter that allows to calibrate the entry rate of our simulations close to stylized facts.

Two important features of new entrants should be determined when they enter into market: productivity and size. According to stylized facts, we assume that an entrant's productivity θ_{it}^e is drawn from a log-normal distribution, with mean $\mu_{\theta_{it}^e}$ linked to incumbents' average productivity Θ_t via the parameter τ_θ and $\tau_\theta \geq 1$.

$$\theta_{it}^e \sim logN(\tau_\theta \Theta_{t-1}, \sigma_{\Theta_{t-1}}^2) \tag{1.26}$$

In a similar way, as a representation of size, a new entrant's output level Y_{it}^e follows a log-normal

distribution. It is independent of the initial productivity value of the firm.

$$Y_{it}^{e} \sim logN(\tau_Y \overline{Y}_{t-1}, \sigma^2_{\overline{Y}_{t-1}}) \tag{1.27}$$

with $\tau_Y < 1$, which means that most of new entrants are smaller than the average size of incumbents.

Each new entrant's price p_{it}^{e} follows a zero-markup based mechanism.

$$p_{it}^{e} = MC_{it}^{e} \tag{1.28}$$

Our modeling also implies the determination of each new entrant's market share at the time of their first appearance in the market, as well as that of incumbent firms. The reallocation of market share includes two dynamics: a new firm enters in the market, produces and sells its products, at the same time, incumbent firms observe that the market demand to their products reduces, then they produce and sell less products.

Consequently, a new firm's market share depends on its initial output level. Denote s_{it}^{e} as its market share, we have

$$s_{it}^{e} = \frac{p_{it}^{e} Y_{it}^{e}}{D_t} \tag{1.29}$$

For the sake of simplicity, assuming that the market demand reduction caused by the entry of new firms is homogeneously distributed to all incumbent firms. Then each existing firm's market share of demand will be

$$s_{it}^{*} = s_{it} - \frac{\sum_i s_{it}^{e}}{N_t^i} \tag{1.30}$$

where N_t^i represents the number of incumbent firms.

Two criteria are established to determine firms' exit. A first threshold is a minimal market share s_{min}: firms with realized market share lower than this limit will be considered as too small

to subsist. The second threshold relies on equity value. Firms with equity value below zero become insolvent, then they should quit the industry.

1.4 Simulation

Following previous research works in the field and stylized facts, we determine a series of values to structural parameters and initial conditions as a benchmark setting. More precisely, the simulations contain 300 initial firms and run for 1000 periods. Table 1.1 and 1.2 give respectively structural parameters and initial conditions of simulations. We also enumerate parameters of new entrants in table 1.3.

Description	Symbol	Value
Capital depreciation rate	δ	0.025
Risk-free interest rate	r_f	0.01
Risk premium coefficient	ρ	0.30
Interest rate spread parameter	ϱ	2
Borrowing limit	b^{thr}	100%
Cost of labor	w	0.5
Mark-up constant	μ_0	0.04
Mark-up parameter	α	20
Mark-up parameter	β	1
Fixed costs	F	8
Market share parameter	λ	1
Market share limit as exit threshold	s_{min}	0.02%
Productivity shock parameter	ϑ	0.8

Table 1.1: Structural parametrization

Description	Symbol	Value
Number of firms	N	300
Number of periods	T	1000
Aggregate demand	D_t	30000
Market share	s_{i1}	0.33%
Debt/assets ratio	b_{i1}	50%
Productivity	θ_{i1}	4.0

Table 1.2: Initial conditions

Description	Symbol	Value
Cost of entry	c_e	1
New entrants number parameter	Ω	1000
New entrants number variance	$\sigma^2_{\chi t}$	0.2
Productivity parameter	τ_θ	1
Productivity variance	$\sigma^2_{\Theta_{t-1}}$	0.05
Output parameter	τ_Y	0.6
Output variance	$\sigma^2_{\overline{Y}_{t-1}}$	0.07

Table 1.3: New entrants calibration

Beginning with the same level of capital and productivity, firms make production decisions under the fluctuations of market demand and the impact of financial constraints. During the simulation, firms' productivity level varies according to periodic shocks, firms evolve with the variations of their financial situation and their decisions taken regarding investment and production. With the mechanism of competition, firms cannot have enough market share have to exit from the market and be replaced by new ones.

We base the calibration of parameters on statistics from empirical studies. For instance, grounded on studies of Meeks (2012), Guntay and Hackbarth (2010) and Loncarski and Szilagyi (2012), we set the main interval of interest rates between 4% and 8%. Even though the distribution of debt ratio is relatively dispersed across countries and sectors, from the statement of de Jong et al. (2011) and Egger et al. (2010), we define all entrants' initial debt to assets ratio as 50 percents.

Through analyzing the simulation results, we can study the evolution of firms' characteristics, particularly we can verify whether the firms stopping their activities have lower productivity level than the survivors.

1.4.1 Benchmark simulation

We carry out first of all reference simulations with stable aggregate conditions to confirm the robustness of the modeling and simulation programming in the present research. The reference simulations also allow us to analyze the main features of firm dynamics as the outcome of our

modeling. Considering in our simulation one period is equivalent to around one quarter, we take a length of 4 periods as one year in our statistical studies.

In the interest of calibrating our model to make the simulation results close to stylized facts, we draw a set of statistics as calibration targets from literature in the area of firm dynamics (see Bellone et al. (2008), Lee and Mukoyama (2012), Bartelsman et al. (2005), Bartelsman et al. (2009) and Cooper and Haltiwanger (2006)).

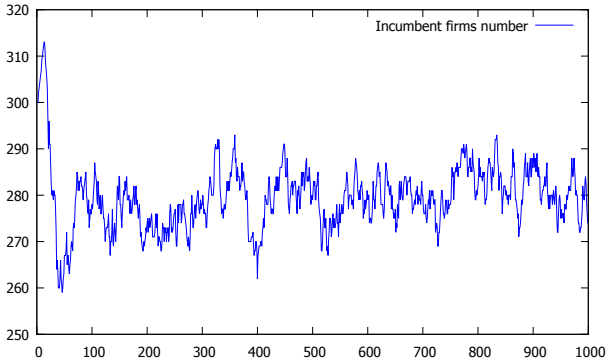
Description	Empirical data Annual	Simulation results			
		Per period		Annualized	
		Mean	Median	Mean	Median
Entry rate	6% - 10%	1.78%	1.73%	7.12%	6.91%
Exit rate	8% - 15%	1.71%	1.69%	6.83%	6.77%
Turnover rate	15% - 20%	3.48%	3.43%	13.94%	13.68%
Entrants' relative size	60%	56.70%	56.64%		
Exitors' relative size	49%	30.63%	30.12%		

Table 1.4: Benchmark simulation - calibration targets

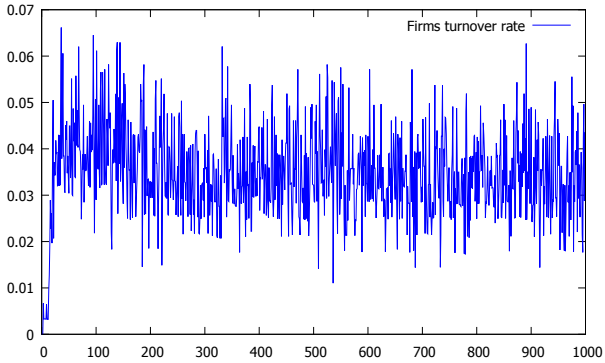
Table 1.4 illustrates a comparison between empirical data and our simulation results in terms of firm dynamics. The results of entry rates, exit rates, turnover rates, new entrants' and exitors' relative size compared to incumbent firms are in line with statistics drawn from stylized facts.

Graphs in figure 1.1 present some basic features of firm dynamics. The number of incumbent firms and turnover rates illustrate a stationary state after 200 periods of simulation, as well as the evolution of Herfindahl index, average markup and average capital return rate, which demonstrate a condition of stable market competition.

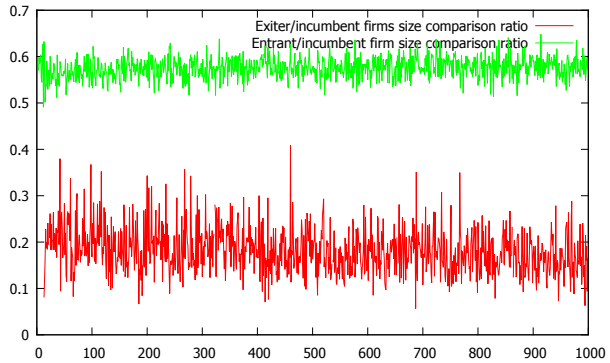
Figure 1.2 displays some main indicators of aggregate dynamics. Aggregate productivity, average price and output vary within a narrow interval. Corresponding to the regularly increasing aggregate productivity, market average price decreases thanks to the reducing labor costs. Meanwhile, the quantity of aggregate output swells progressively. We peculiarly notice that the weighted average productivity remains slightly higher than the arithmetic average one, even though both fluctuate in the same rhythm. This is due to the rising weight of relatively more productive firms in the industry. Under the effect of market selection, more efficient firms gain market share and



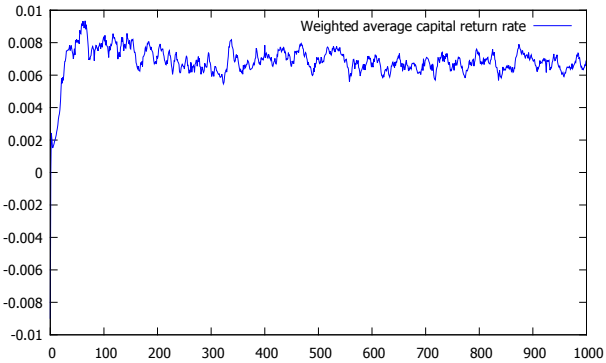
(a) Incumbent firm number



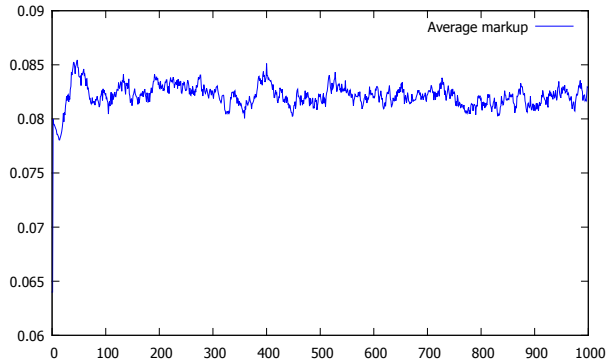
(b) Firm turnover rate



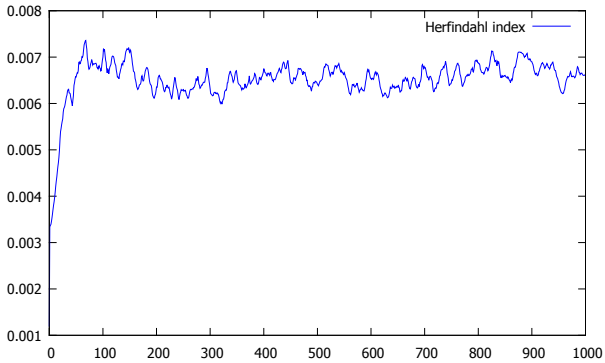
(c) Exitor, entrant and incumbent firms size comparison



(d) Weighted average capital return rate

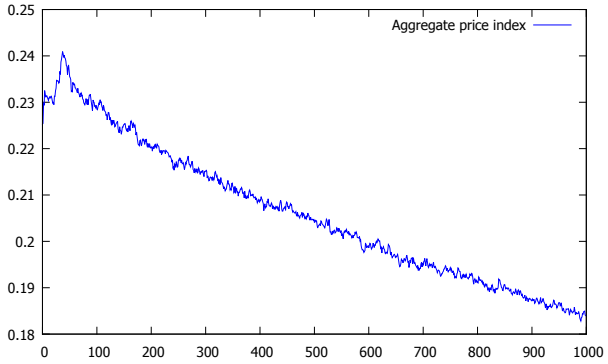


(e) Average markup

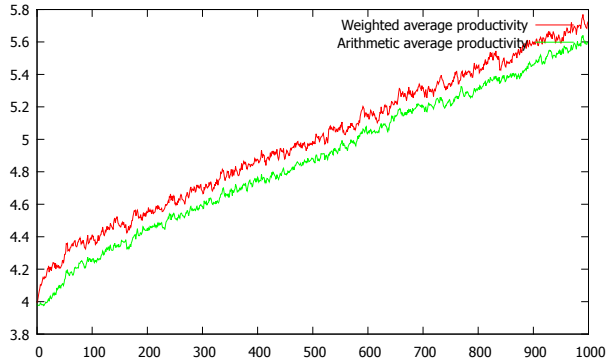


(f) Herfindahl index

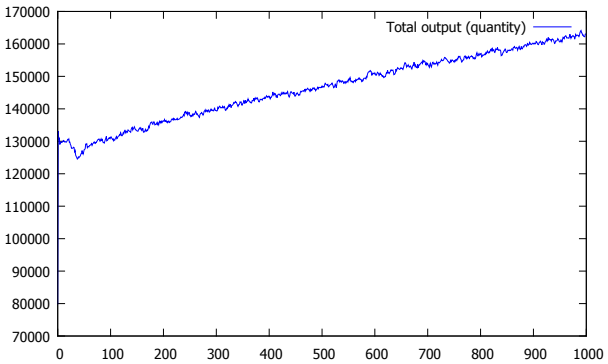
Figure 1.1: Benchmark simulation - aggregate dynamics



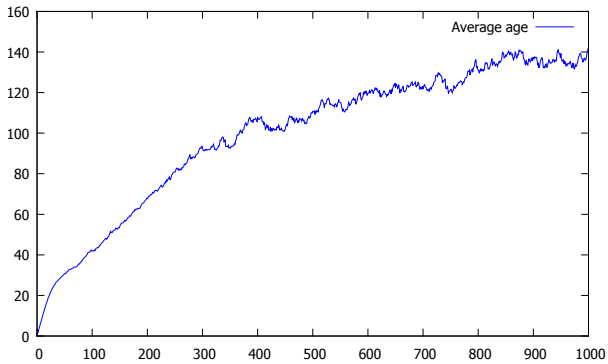
(a) Aggregate price index



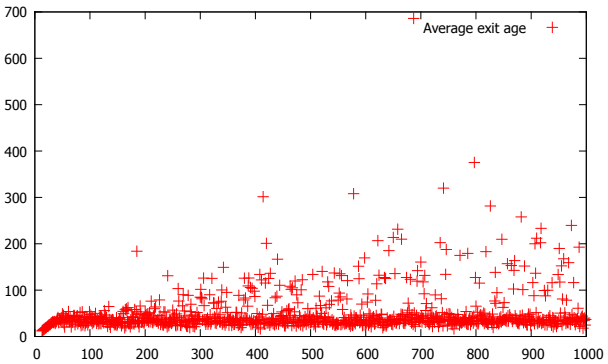
(b) Arithmetic and weighted average productivity comparison



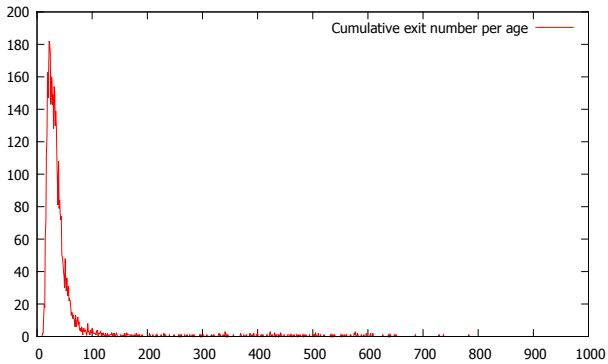
(c) Aggregate output in quantity



(d) Average age

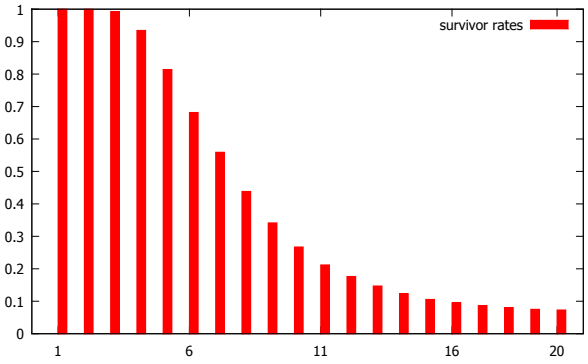


(e) Average exit age



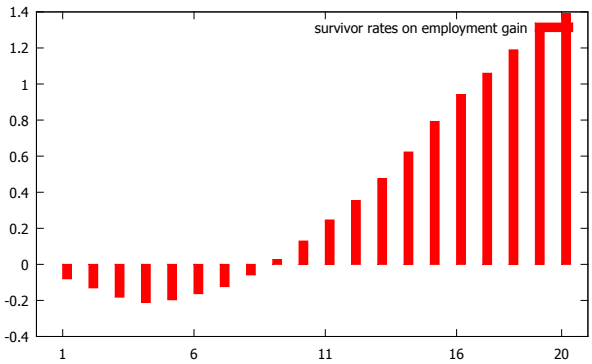
(f) Cumulative exit number per age

Figure 1.2: Benchmark simulation - aggregate dynamics



(a) Firm survivor rates at different lifetime

(b) Employment-based survivor rates at different lifetime



(c) Net employment gains of surviving firms at different lifetime

Figure 1.3: Benchmark simulation - survivor rates

become bigger than the rest of the firms. Consequently, the weighted average level persists upper.

In line with empirical data, the graph of cumulative exit number per age shows that young firms occupy the absolute majority among those quit the market. The graph of average exit age gives the same interpretation.

Figure 1.3 presents graphs of analysis related to survivor. Compared to empirical studies (see e.g. Bartelsman et al. (2005)), our simulation results are in line with stylized facts. We introduce three types of indicator: firm survivor rate, employment-based survivor rate which measures on average the proportion of total labor quantity of surviving firms within all firms entered into market, and net employment gain of surviving firms which represents the average growth of survivors compared to their initial size while joining the industry. The three graphs illustrate that firm survivor rates decrease with age before leveling off at age of eleven, as well

as the evolution of employment-based survivor rates. Net employment gains of survivors remain slightly negative after entry, then increase relatively fast. As mentioned in previous empirical works, young firms have a particularly high rate of failure. Even though some young firms can endure in market competition, they struggle to grow, as shown the negative employment gain of survivors with low ages. The combination of low survival rate and weak employ gain at young age makes the employment-based survivor rates decrease rapidly after firms' entry into market. Equally as explained in several existing studies, the poor survival rates and post entry performance of young firms are mainly due to the more stringent financial constraints and unfavorable size effects that they face. This aspect is analyzed in detail in the subsequent sections.

1.4.2 Quantitative analysis

Age	θ	UC	p	b	r	K	L	K/L
1	1.00	0.99	0.99	1.25	1.10	0.57	0.59	0.91
2	1.00	1.03	1.00	1.36	1.14	0.58	0.58	0.96
3	1.00	1.09	1.00	1.48	1.19	0.57	0.56	1.04
4	1.00	1.13	1.01	1.60	1.24	0.57	0.55	1.10
5	1.00	1.12	1.01	1.70	1.27	0.58	0.56	1.09
6	1.01	1.10	1.01	1.77	1.30	0.61	0.58	1.07
7	1.01	1.08	1.01	1.80	1.32	0.64	0.61	1.05
8	1.02	1.05	1.01	1.80	1.32	0.70	0.67	1.03
9	1.02	1.03	1.01	1.79	1.32	0.76	0.73	1.03
10	1.03	1.01	1.01	1.75	1.31	0.82	0.79	1.02
11	1.03	0.99	1.01	1.71	1.29	0.88	0.86	1.01
12	1.04	0.98	1.01	1.67	1.28	0.93	0.90	1.01
13	1.04	0.98	1.01	1.62	1.26	0.98	0.95	1.01
14	1.04	0.97	1.01	1.57	1.24	1.02	0.98	1.01
15	1.04	0.96	1.00	1.51	1.21	1.07	1.04	1.00
16	1.05	0.94	1.00	1.45	1.19	1.12	1.10	0.99
17	1.05	0.93	1.00	1.40	1.17	1.18	1.16	0.99
18	1.05	0.93	1.00	1.36	1.15	1.22	1.20	0.99
19	1.04	0.93	1.00	1.29	1.13	1.26	1.24	0.99
20	1.04	0.92	1.00	1.21	1.09	1.30	1.29	0.98

Table 1.5: Benchmark simulation - post entry performance of firms, relative to industry average

Tables 1.5 and 1.6 validate the statements about firm dynamics in our benchmark simulations

Age	θ	UC	p	b	r	K	L	K/L
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	1.00	1.04	1.00	1.08	1.04	1.02	0.98	1.06
3	1.00	1.09	1.01	1.17	1.08	1.01	0.95	1.14
4	1.00	1.13	1.01	1.26	1.12	1.01	0.93	1.20
5	1.01	1.12	1.02	1.33	1.15	1.02	0.94	1.19
6	1.01	1.10	1.02	1.39	1.18	1.06	0.97	1.16
7	1.02	1.08	1.02	1.43	1.20	1.12	1.03	1.15
8	1.02	1.06	1.02	1.44	1.20	1.22	1.12	1.13
9	1.03	1.04	1.02	1.43	1.20	1.31	1.20	1.13
10	1.03	1.01	1.02	1.41	1.19	1.43	1.32	1.11
11	1.04	1.00	1.02	1.38	1.18	1.54	1.43	1.10
12	1.04	0.99	1.01	1.34	1.17	1.62	1.50	1.11
13	1.04	0.99	1.01	1.31	1.15	1.70	1.57	1.11
14	1.04	0.98	1.01	1.27	1.13	1.76	1.63	1.11
15	1.04	0.96	1.01	1.22	1.11	1.83	1.71	1.10
16	1.05	0.95	1.01	1.17	1.09	1.94	1.81	1.09
17	1.05	0.94	1.00	1.13	1.07	2.04	1.92	1.09
18	1.05	0.94	1.01	1.09	1.05	2.11	1.98	1.09
19	1.04	0.94	1.01	1.04	1.03	2.17	2.04	1.09
20	1.04	0.93	1.01	0.98	1.00	2.21	2.09	1.07

Table 1.6: Benchmark simulation - post entry performance of firms, relative to first year of entry

through quantitative analysis. Respectively compared to the industry average and the first year after entry, these two tables list the evolution of surviving firms through eight major indicators: productivity (θ), unit cost (UC), price (p), debt ratio (b), interest rate (r), capital (K), labor (L) and capital intensity (K/L).

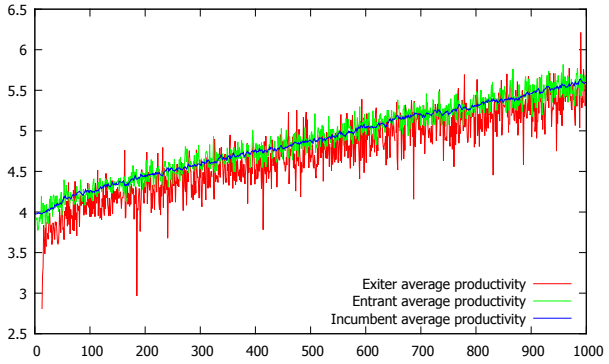
For the table of post entry performance of firms relative to industry average, the values are calculated for each period as the comparison between each indicator of a firm of a certain age and the sectoral mean of all firms of a different age. The table covers a range from one to twenty years and gives a clear demonstration of the evolution of survivors in contrast to the industry average, with reference to different key aspects. The following equation stands for the calculation.

$$\chi^{ri}_{it,a} = \chi_{it,a}/\overline{\chi}_{it,b\neq a} \tag{1.31}$$

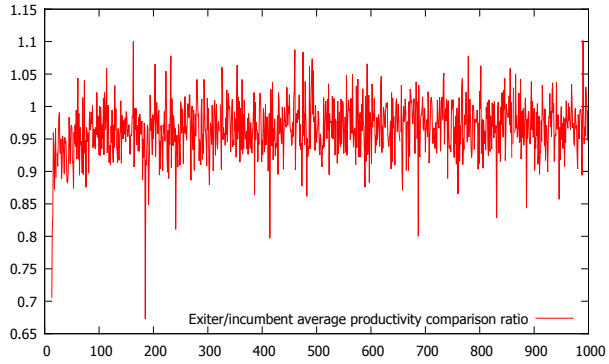
where $\chi^{ri}_{it,a}$ represents the indicators of comparison, a and b describe two distinct ages.

From table 1.5 we observe that the average size of survivors - represented by capital and labor - starts at a relatively low level but enlarges rapidly after their entry and attain a level superior to industry average, before entering into phase of stagnation. Firms enter into the market with the industry average level of productivity, then their average efficiency increases progressively. Correspondingly, the average unit cost decreases regularly as soon as spiking short term after entry. The variation of unit cost in early stage is arisen from the fact that young firms are mostly smaller than incumbents which induces higher unit cost, but once they grow up this disadvantage disappears. The same size effects to young firms brings on the increase of their average debt ratio after entry due to the predicament in terms of profit. The size effects taper off while firms expanding, which explains the later diminution of debt ratio because firms' get more profitable. As interest rates are determined contingent upon debt ratio, their averages have the similar variations.

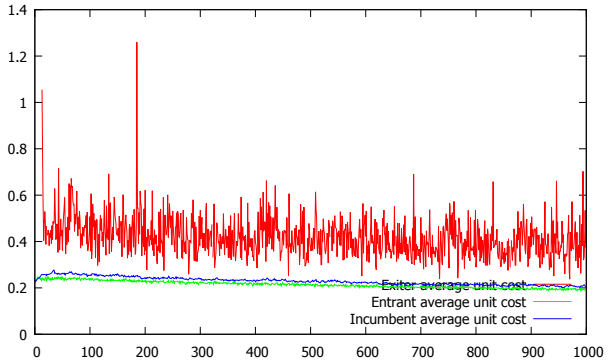
In a similar way, to the table of post entry performance of firms relative to the first year after entry, the calculation is realized by comparing for each period the main factors of survivors of a given age to the average of those just entered into the market, with expression:



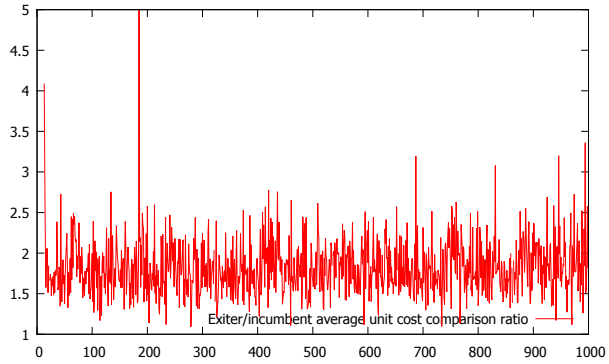
(a) Productivity comparison



(b) Productivity comparison



(c) Unit cost comparison



(d) Unit cost comparison

Figure 1.4: Benchmark simulation - productivity and unit cost

$$\chi_{it,a}^{re} = \chi_{it,a} / \overline{\chi}_{it,a=1} \tag{1.32}$$

We notice in table 1.6 that compared to their first year after entry, the average size of survivors doubled within nine years then remains stable during the rest of their time. The average capital intensity swells as survivors' average productivity of labor is improving. Similar to the preceding table, due to the size effects to young firms, their average debt ratio and interest rate increase after entry, as well as the unit cost. Then the two former indicators decrease as survivors' financial situation is improved, thanks to the dented size effects and the progress of productivity. The same factors can equally explain the diminishing average unit cost.

Figure 1.4 consists of graphs related to productivity and unit cost analysis. Notice that the average productivity of exiting firms is in general lower than the level of incumbent ones. As

Description	Exitor	Entrant	Incumbent
Mean	4.72	4.88	4.88
Median	4.51	5.01	4.99
Standard deviation	0.48	0.35	0.49
Two-sample t test with incumbent firm: p-value (degree of freedom: 5)	0.00	0.96	

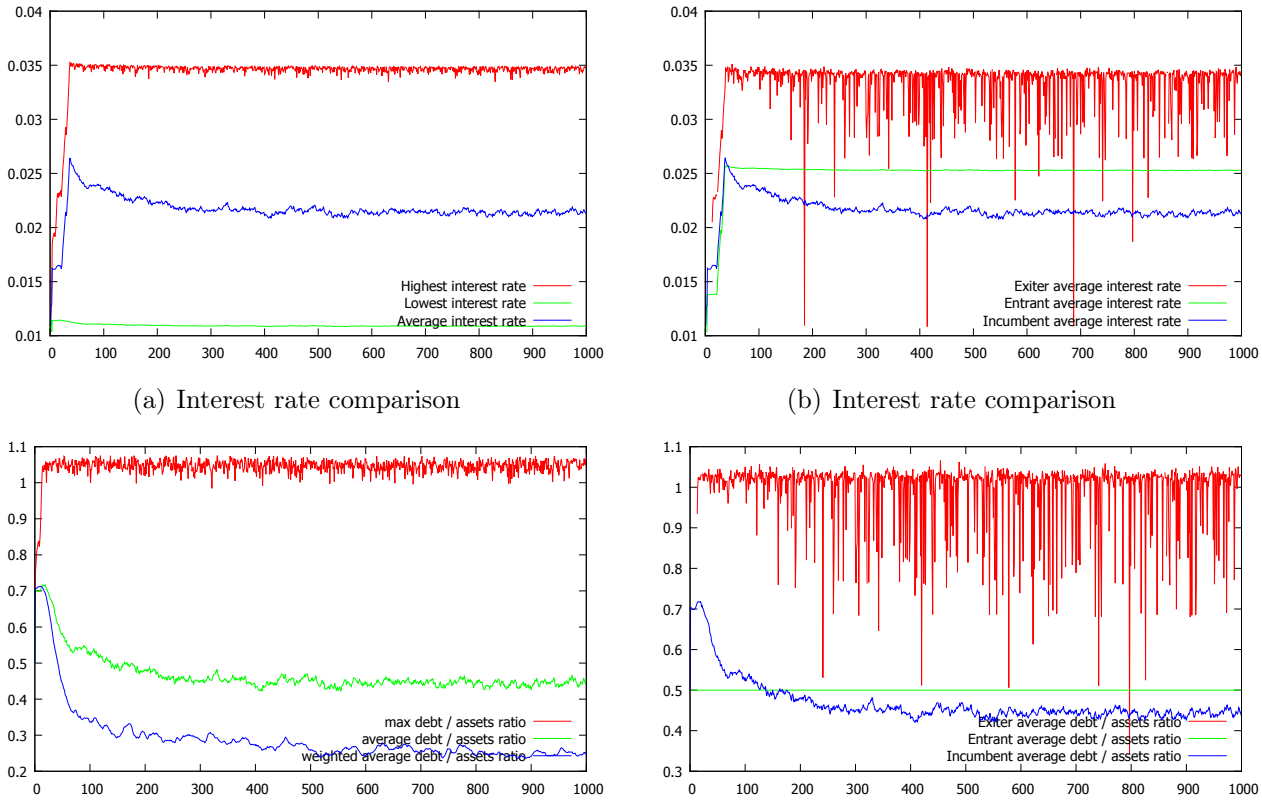
Table 1.7: Benchmark simulation - productivity analysis statistics

Description	Exitor	Entrant	Incumbent
Mean	0.27	0.17	0.17
Median	0.17	0.17	0.16
Standard deviation	0.09	0.01	0.04
Two-sample t test with incumbent firm: p-value (degree of freedom: 5)	0.00	0.00	

Table 1.8: Benchmark simulation - unit cost analysis statistics

Description	Exitor	Entrant	Incumbent
Mean	0.17	0.15	0.16
Median	0.16	0.15	0.16
Standard deviation	0.01	0.01	0.01
Two-sample t test with incumbent firm: p-value (degree of freedom: 5)	0.00	0.00	

Table 1.9: Benchmark simulation - Price analysis statistics



(a) Interest rate comparison

(b) Interest rate comparison

(c) Debt/assets ratio comparison

(d) Debt/assets ratio comparison

Figure 1.5: Benchmark simulation - debt/assets ratios and interest rates

we define the mean of new entrants' productivity equal to that of incumbents in the first period, consequently, the average of new entrants' productivity stays at the same level as the average of firms remaining in the market. In the graph 1.4(b), the comparison ratio between these two categories of firms remains mainly below 1, which confirm the statement of preceding graph. Corresponding to the affirmation of productivity analysis, firms exiting the market have a higher unit cost than those who subsist. The situation is once again corroborated by the comparison between the two groups of firms in graph 1.4(d), where the average unit cost of exitors are mostly higher than the one of incumbents. Tables 1.7, 1.8 and 1.9 give statistics demonstrating that exiting firms are in average less efficient and have higher unit cost and higher price. Therefore, the mechanism of market selection works even with the presence of financial constraints. This statement is in concordance with empirical results.

Figure 1.5 gives dynamics of interest rates and debt ratios. Due to the existence of financial

Description	Exitor	Entrant	Incumbent
Mean	95.34%	50.00%	48.24%
Median	100.77%	50.00%	53.74%
Standard deviation	0.18	0.00	0.35
Two-sample t test with incumbent firm: p-value (degree of freedom: 5)	0.00	0.00	

Table 1.10: Benchmark simulation - debt/assets ratio analysis statistics

Description	Exitor	Entrant	Incumbent
Mean	10.45%	8.23%	7.42%
Median	10.74%	8.23%	7.86%
Standard deviation	0.00	0.00	0.01
Two-sample t test with incumbent firm: p-value (degree of freedom: 5)	0.00	0.00	

Table 1.11: Benchmark simulation - interest rate analysis statistics

constraints where interest rates are geared to debt ratios, as the gap in debt ratios and interest rates between incumbent firms and exiting ones is distinct. The evident difference between the maximal, minimal and average interest rates interprets the impact of financial constraints on cost of capital and the dynamics of firms. As an explanatory factor to the distinction of interest rates, the average debt ratio of exiting firms is far above that of incumbents. The quantitative analyses given in tables 1.10 and 1.11 sustain our interpretations. We remark in these two tables that interest rates of exitors are significantly higher than those of incumbents because of the high debt ratios of the former, due to accumulated losses which bring about difficult financial situation.

We also establish a set of quintile analyses on characteristics of survivors and exitors. For instance, in order to realize the quintile of relative distribution of productivity, we calculate for each period the productivity of each firm i relative to all firms with a different age in the sector. Then we rank the results in increasing order, split in five equal portions, and distinguish respectively the part of survivors and exitors within their total number in percentage. The calculation could be formulated via the following expression:

$$ln\theta^{ri}_{it,a} = ln\theta^{S}_{it,a} - ln\overline{\theta}^{s}_{t} \tag{1.33}$$

where $ln\overline{\theta}^{s}_{t}$ is logarithm of the arithmetic average of productivity of firms with ages different from a in the sector S at period t, more exactly

$$ln\overline{\theta}^{s}_{t} = \frac{1}{n}\sum_{i\in S}^{n} ln\theta^{S}_{it,b\neq a} \tag{1.34}$$

where a and b represent age of firms.

Quintile	Age <= 3		Age >=10	
	Exitors	Survivors	Exitors	Survivors
1	100.00	19.99	25.32	19.94
2	0.00	20.00	20.87	19.99
3	0.00	20.00	21.06	19.99
4	0.00	20.00	19.11	20.01
5	0.00	20.01	13.64	20.07
	100.00	100.00	100.00	100.00

Table 1.12: Benchmark simulation - relative productivity distribution

Quintile	Age <=3		Age >=10	
	Exitors	Survivors	Exitors	Survivors
1	0.00	20.00	0.00	20.21
2	0.00	20.00	0.19	20.21
3	0.00	20.00	1.58	20.19
4	0.00	20.00	12.24	20.08
5	100.00	20.00	85.99	19.32
	100.00	100.00	100.00	100.00

Table 1.13: Benchmark simulation - relative unit cost distribution

Table 1.12 gives the quintile of relative productivity distributions for exitors and survivors, with age up to three years or more than nine years. The two columns related to exitors show that firms exiting from the market are mainly less efficient than those stay in the industry. However, we notice that not all exitors are concentrated in the first quintile, where the productivity is the lowest in the industry. This result indicates that within the market competition productive efficiency is not

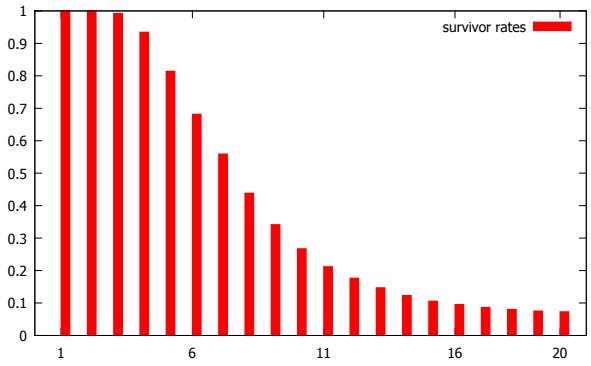
the unique determinant of firms' dynamics. By comparing the two groups of firms distinguished by age, we observe that the distribution of exitors is more intensive while age increases. It is evident that the influence of productivity on firms' survival becomes more important with age, the chance of survive for young firms depends more on other factors than productivity. Here again, our results are very close to those of empirical studies (see e.g. Bellone et al. (2008)).

A similar quintile statistics is also carried out on firms unit cost. The results presented in 1.13 confirm our statement: exitors have in general higher unit cost, jointly due to lower productivity which raises costs of labor and high debt ratio which pumps up costs of capital. The concentration of distribution in higher unit cost is more obvious for mature firms as result of elimination of young firms in market.

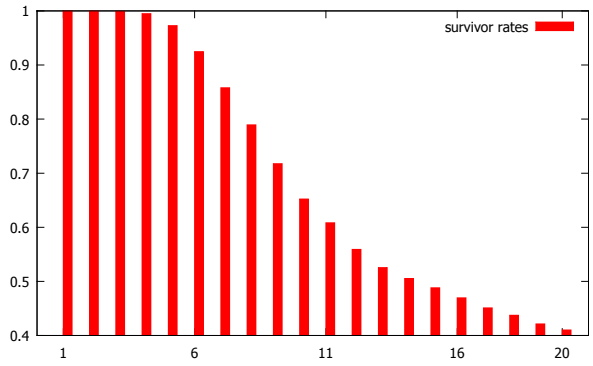
1.4.3 Effects of financial constraints

We also check the effects of financial constraints on firms, especially young firms in our simulations. To realize this, we set a scenario of "perfect financing conditions" where financial restrictions are absent. We do so by removing the variable part of interest rate determination and credit rationing based on the limitation on debt ratio. As a result, interest rates become equal to risk-free rate to all firms, and firms can borrow as much as they need.

Figure 1.6 shows us a comparison of survival rates between the scenario with financial constraints and the test scenario without financial constraints. The survival rates on employment and employment gain illustrate a obvious difference between these two scenarios. With the presence of financial constraints, the average employment-based survival rate decreases rapidly at the beginning, before reaching a stable level at the age of twelve. While the restrictions are taken out, the same indicator increases fast and crests at the age of six. The comparison obviously displays the impact of financial constraints on firm dynamics, especially the growth of young firms. Similar statement could be obtained through the contrast of net employment gains of survivors between the two scenarios. Without restraining financial environment young firms expand promptly instead of shrinking in the contrary context. Moreover, the size differential between incumbent firms are



(a) Firm survivor rates at different lifetime (with financial constraints)

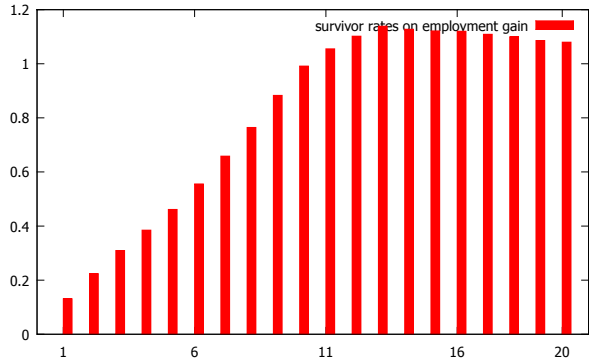


(b) Firm survivor rates at different lifetime (without financial constraints)

(c) Employment-based survivor rates at different lifetime (with financial constraints)

(d) Employment-based survivor rates at different lifetime (without financial constraints)

(e) Net employment gains of surviving firms at different lifetime (with financial constraints)



(f) Net employment gains of surviving firms at different lifetime (without financial constraints)

Figure 1.6: Survivor rates comparison - with and without financial constraints

less important when financial restrictions are absent: large firms are hence less favored in bank lending market where firms with low ages and small size are usually penalized. All in all, it is clear that financial constraints play an vital role in firm dynamics in our simulations, which is in accordance with conclusions of preceding empirical studies.

1.4.4 Shock of demand

As we have noticed during the financial crisis started in 2008, squeezed market demand drove increasing bankruptcy waves. In the meantime, banks getting more and more alarmed tightened gradually firms' financing conditions by restricting loan volume and amplifying differentiation in interest rates. As a result, the impact of financial constraints aggravated as interest rate spread enlarged and increasing number of firms suffered credit rationing.

In this scenario, we set a sudden market demand contraction of 25% in the middle of simulation, more precisely in period 500, then total market demand remains the level after the plummet. We then analyze the features of exitors and survivors after the shock of demand for short and medium term, respectively two and six years after shock. We perform quantitative analysis through a battery of tables. Tables 1.14 to 1.21 show the after-shock short and medium term evolution of incumbents, entrants and exitors in terms of productivity, unit cost, debt/assets ratio and interest rates.

Table 1.14 reveals the key information to this scenario. Up to two years after the shock of demand, there is no difference between the productivity of exitors and that of surviving firms. Based on this statement, it is evident that the market selection mechanism does not work with the presence of financial constraints and shock of demand. This argument is confirmed by the analysis in table 1.22. We remark in the table of quintile that the relative productivity distribution for young firms that quit the market does not follow the pattern in the scenario without shock of demand: instead of a distribution partly concentrated in classes of low productivity, with the shock of demand, the distribution is almost equal in all grades, from the lowest to the highest level of productivity. Therefore the market selection through efficiency is not functioning in the

circumstances.

Furthermore, the results are similar for both short and medium term after the shock, the distribution of exitors' productivity does not tend to low productivity, which means that the negative impact of aggravating global demand on the functioning of market selection process could be persistent.

The explanation to such dysfunction could be found via the analysis of table 1.18 to table 1.21. Even though the average debt ratio and interest rate of incumbents remains relatively stable, the median value of these two indicators are highly increased. This shows us that the contraction of demand has pushed a big number of incumbent firms into difficulties, therefore their debt ratio is largely deteriorated. As a consequence, these firms suffer a heavy financial restriction in terms of interest rates and access to bank lending. In the sight of bank, solvency is a crucial criterion: firms with poor solvency have to face higher interest rates to compensate the risk of default and even credit rationing to limit the potential damage due to future default. A better profitability due to higher productivity will not change a firm's financial situation immediately. New entrants and small firms suffer more within such context: these firms generally have high probability to fail market competition because of their insufficient size. A slump of macroeconomic environment makes these firms still more vulnerable, and their financial conditions harder to improve, even with a proper productivity level.

To sum up, the combination of financial constraints and shock of demand, or more generally deteriorating macroeconomic conditions, can result an inefficient market competition: firms - especially of small and middle size or young age - exit from the market but with the same level of productivity compared to those remain incumbent. Therefore, the progression of aggregate productivity which is the consequence of market competition cannot meet its optimal level.

Description	Exitor	Entrant	Incumbent
Mean	4.65	4.74	4.68
Median	4.80	4.69	4.26
Standard deviation	0.39	0.14	0.39
Two-sample t test with incumbent firm: p-value (degree of freedom: 5)	0.63	0.77	

Table 1.14: Shock of demand - productivity analysis statistics (short term after shock)

Description	Exitor	Entrant	Incumbent
Mean	4.53	4.66	4.68
Median	4.79	4.70	4.75
Standard deviation	0.34	0.19	0.38
Two-sample t test with incumbent firm: p-value (degree of freedom: 5)	0.00	0.57	

Table 1.15: Shock of demand - productivity analysis statistics (medium term after shock)

Description	Exitor	Entrant	Incumbent
Mean	0.26	0.17	0.19
Median	0.25	0.17	0.24
Standard deviation	0.07	0.00	0.05
Two-sample t test with incumbent firm: p-value (degree of freedom: 5)	0.00	0.34	

Table 1.16: Shock of demand - unit cost analysis statistics (short term after shock)

Description	Exitor	Entrant	Incumbent
Mean	0.25	0.17	0.18
Median	0.24	0.17	0.17
Standard deviation	0.07	0.00	0.04
Two-sample t test with incumbent firm: p-value (degree of freedom: 5)	0.00	0.33	

Table 1.17: Shock of demand - unit cost analysis statistics (medium term after shock)

Description	Exitor	Entrant	Incumbent
Mean	99.21%	50.00%	48.68%
Median	100.25%	50.00%	83.61%
Standard deviation	0.16	0.00	0.37
Two-sample t test with incumbent firm: p-value (degree of freedom: 5)	0.00	0.00	

Table 1.18: Shock of demand - debt/assets ratio analysis statistics (short term after shock)

Description	Exitor	Entrant	Incumbent
Mean	100.17%	50.00%	42.55%
Median	108.87%	50.00%	71.93%
Standard deviation	0.12	0.00	0.38
Two-sample t test with incumbent firm: p-value (degree of freedom: 5)	0.00	0.13	

Table 1.19: Shock of demand - debt/assets ratio analysis statistics (medium term after shock)

Description	Exitor	Entrant	Incumbent
Mean	10.49%	8.23%	7.42%
Median	10.59%	8.23%	9.13%
Standard deviation	0.00	0.00	0.01
Two-sample t test with incumbent firm: p-value (degree of freedom: 5)	0.00	0.48	

Table 1.20: Shock of demand - interest rate analysis statistics (short term after shock)

Description	Exitor	Entrant	Incumbent
Mean	10.55%	8.18%	7.03%
Median	10.70%	8.18%	8.95%
Standard deviation	0.00	0.00	0.01
Two-sample t test with incumbent firm: p-value (degree of freedom: 5)	0.00	0.00	

Table 1.21: Shock of demand - interest rate analysis statistics (medium term after shock)

Quintile	Age <=3		Age >=10	
	Exitors	Survivors	Exitors	Survivors
1	29.58	18.96	50.00	19.93
2	18.31	20.08	33.33	19.96
3	15.49	20.37	0.00	20.04
4	15.49	20.37	0.00	20.04
5	21.13	20.22	16.67	20.04
	100.00	100.00	100.00	100.00

Table 1.22: Shock of demand - relative productivity distribution (short term after shock)

Quintile	Age <=3		Age >=10	
	Exitors	Survivors	Exitors	Survivors
1	23.38	19.75	65.38	19.79
2	19.48	20.02	15.38	20.02
3	24.68	19.66	7.69	20.05
4	19.48	20.02	0.00	20.09
5	12.99	20.56	11.54	20.05
	100.00	100.00	100.00	100.00

Table 1.23: Shock of demand - relative productivity distribution (medium term after shock)

Quintile	Age < 3		Age > 9	
	Exitors	Survivors	Exitors	Survivors
1	8.45	21.07	0.00	20.04
2	15.49	20.37	0.00	20.04
3	19.72	19.94	16.67	20.00
4	11.27	20.79	16.67	20.00
5	45.07	17.84	66.67	19.93
	100.00	100.00	100.00	100.00

Table 1.24: Shock of demand - relative unit cost distribution (short term after shock)

Quintile	Age < 3		Age > 9	
	Exitors	Survivors	Exitors	Survivors
1	9.09	20.74	0.00	20.09
2	9.09	20.74	3.85	20.07
3	16.88	20.20	0.00	20.09
4	24.68	19.66	7.69	20.05
5	40.26	18.67	88.46	19.70
	100.00	100.00	100.00	100.00

Table 1.25: Shock of demand - relative unit cost distribution (medium term after shock)

1.5 Conclusion

Through an agent-based model, this research work tries to analyze market selection process from the viewpoint of financial constraints and deterioration of market demand. The main characteristics of our simulation correspond to statistics of empirical studies with regard to firm dynamics.

The simulation results demonstrate a plausible failure of market selection mechanism during periods when economic environment is distressed. The combination of financial constraints and shock of demand is the key explanatory factor to such dysfunction. Financial constraints - acting via varying interest rates and possible credit rationing contingent on firms' debt ratio - result a gap between the selection in market of products and market of bank lending. A short-term amelioration of profitability due to higher productivity cannot immediately improve a firm's solvency then its financing conditions. The negative effects of financial restrictions could be intensified by the deterioration of macroeconomic environment such as contraction of market demand. An increasing number of firms - mainly small or middle size and young age - exit from the market for the reason of poor financial robustness instead of lower productivity. There is no significant difference between productivity of exiting firms and incumbents. As a direct consequence, aggregate productivity improvement could be derived from expected trajectory. The impact of deteriorating macroeconomic conditions could be persistent by modifying the structure of market competition.

The results of our research could challenge the existing theories at a fundamental level: if the selection mechanism of firms grounded on efficient market fails to function as expected during recession, which means firms with higher productive performance exit from the market however those with lower productivity survive, the efficiency of competitive market which is considered as foot-stone of our whole economic system and economic policy decisions should be questioned. Moreover, our results challenge the arguments of "cleansing effects" by demonstrating the plausible contrary outcome with similar macroeconomic contraction background.

At the same time, this study equally questions the role of financial system in economic recovery, competitive market functioning and productivity growth at macroeconomic level.

Consequently, how to maintain a relatively accessible financing environment to firms in order to

avoid dysfunction of market selection mechanism and distortion of market competition structure, especially with unfavorable macroeconomic conditions, is one of the main issues of actual economic policy. Even though the main objective - easing firms lending from financial intermediaries - remains clear, rare are relevant measures adopted.

The recent proposition of French government to create a public investment bank aiming at financing directly enterprises could be a hopeful attempt. However, other levers may be used to improve the tightrope that firms are facing, from both borrowers' and lenders' side. For example, central banks may constrain financial institutions' access to cheap money only to those supplying firms fresh loans. It could also be helpful for governments to consider introducing mechanisms to cover outstanding firm credits on banks' books. Or even more, purchasing directly business debt by government from commercial banks may have still more efficient results. Altogether, all the steps target on compelling banks to play their role in real economy hence tapering off the effects of liquidity frictions.

Chapter 2

R&D investment patterns, financial constraints and macroeconomic conditions

Abstract

We build an agent-based model to study the effects of financial constraints and macroeconomic fluctuations on firms' investment in Research and Development (R&D). The simulation results show that the coalescence of presence of financial constraints and uncertainty of return on R&D investment is a detriment to firms with high innovation intensity, because of their less robust financial situation in short term. Deteriorating macroeconomic conditions aggravate the disparity between firms of distinct R&D investment patterns. The excessive elimination of firms engaging intensive R&D investment in economic downturn distorts the market structure to the advantage of firms with more conservative investment patterns. Long-run economic growth could be affected as R&D investment is discouraged.

Keywords: firm dynamics; R&D investment; financial constraints.

2.1 Introduction

Considered as commonly acknowledged, research and development (R&D) are one of the main driver of long-run economic growth. Even though there is no doubt about the positive impact of R&D investment and its outcome - innovation - on economy, in a traditional way, research works studying the subject assume that R&D investments can be financed without constraints (see e.g. Berk et al. (2004)). Trying to get closer to reality, some recent studies focus on the impact of financial constraints on R&D activities or innovation, and confirm that the effects are negative and significant (see e.g. Hyytinen and Toivanen (2005)).

Whereas the question about the impact of financial constraints on R&D investment could go beyond the firm level. Brown et al. (2012) suggests that the existence of financial frictions could restrict R&D investment below its optimal level that firms could realize without financing constraints. Considering the spillover effects of knowledge, the negative impact of financial constraints on certain firms' R&D may spread across firms, sectors even countries. Therefore, the effects may surpass the initial firms where the constraints strike, up to economic growth.

The recent economic recession shows us an increasingly stringent financing conditions to firms. Such obstruction together with distressed economic environment could put supplementary pressure on firms by making them financially more fragile. However, for a firm, one of the main determinants of the investment in R&D is its financial situation. Accordingly, given the heterogeneity of firms in terms of innovation intensity, what could be the effects of financial constraints combined with declining macroeconomic environment on firms' survival likelihood?

In this paper, we study the evolution of firms' R&D investment patterns with the presence of financial constraints and deteriorating macroeconomic conditions. We build an agent-based model, in which firms produce a homogeneous product by dint of productive factors input including capital, labor and raw material and intermediate goods. Heterogeneity across firms takes shape in different R&D investment patterns and in consequence different productivity level, financial conditions, production decisions and size. The competition between firms is realized based on price. Firms failing in competition exit from the market, meanwhile new ones attracted by profit

join the industry.

Fagiolo and Dosi (2003) introduce two types of R&D activities, exploration and exploitation representing respectively two aspects of innovation. The first one indicates research in new field with high uncertainty of outcome, the second one describes imitation of others in close field with logically, relatively lower uncertainty. Correspondingly, we distinguish in our research two types of R&D activities. In our modeling, each firm has a degree ranged from zero to one to measure the proportion of profit decided to be engaged for physical capital or R&D activities. Furthermore, within the R&D investment of every firm, a second measure, also varies from zero to one, indicates the percentage of investment dedicated to non-risky or risky projects. Hence, the first measure allows to categorize firms into pro-capital or pro-R&D groups regarding their investment intent. The second measure classifies firms as pro-safe or pro-risky R&D profiles. These two indicators then give us the possibility to study in the simulation firm dynamics in terms of their R&D investment patterns.

The simulation results show us a clear distortion of market structure with reference to the categories of firms regarding their R&D investment patterns. Under the influence of financial constraints and declining macroeconomic conditions, firms with high innovation intensity, especially those invest mainly in risky research projects have higher probability to be eliminated in market competition, inasmuch as investment in R&D generally has higher uncertainty of return than in physical capital, and in the short term explorative R&D projects have lower probability of outcome realization than R&D activities in more traditional area. On the contrary, because of the relatively stable return generated by investment in physical capital, firms with more conservative R&D investment perspective have more chance to survive economic downturn. Such unequal firm dynamics regarding their R&D investment patterns could have crucial consequences on aggregate productivity progression and long-run economic growth.

The contribution of the present research consists in supplementing the existing literature by analyzing firm dynamics from the angle of R&D investment patterns, taking into account the impact of both financial constraints and deteriorating macroeconomic conditions. Previous research

works relative to the subject mainly focus on the effects of financing frictions upon investment in R&D and innovation. Among them, there exist a big number of empirical studies examining the effects. Even though certain results of these research works remain contradictory, the majority confirms that financial restrictions have a significant impact on firms' R&D activities. However, the extend of the effects is different across countries, precisely more important in US than Europe. Brown et al. (2012) gives a review of literature related to this topic.

Empirically, Hyytinen and Toivanen (2005) base on Finnish SME data prove that capital market imperfections impede firm innovation and growth. Studies based on data of other countries, such as Canepa and Stoneman (2008) on UK firms, Savignac (2008) from French firms, Mohnen et al. (2008) for firms in Netherlands, find that the impact of financial constraints is more important to small firms and high tech sectors. Financial barriers to innovation take form as both the cost and availability of financing resources.

Li (2011) finds a strong interaction effect between financial constraints and R&D investment on expected returns, which means that the relation between financial constraints and return reinforces with the R&D intensity, as well as the R&D intensity - return relation increases with financial constraints.

On the other hand, through various angles, other theoretical studies try to explain the relationship between financial constraints and firms' R&D activities, in particular the reason why the financing of R&D could be restricted. Hyytinen and Toivanen (2005) demonstrate the theoretic foundation of the impact of capital market imperfection on firms R&D activities and their growth. They explain the fact that marginal cost of capital is an increasing function of R&D investment when capital market is imperfect, contrary to the case of perfect capital market where the marginal cost would be inelastic. Because of such increasing marginal cost of capital, the marginal rate of return is a decreasing function of R&D investment. Arisen from the existence of capital market imperfections, the upward slope of marginal cost of capital brings about the relation that firms - mainly young and small firms - are more restrained in their R&D investment if they are more depending on external finance. This restriction constitutes the principle factor of the obstacle to

firms' growth.

Hall (2002) argues that in contrast to the rest of firms, the marginal cost of capital of small firms could have a steeper slope for a given value of R&D investment, because of the uncertainty in outcome of R&D activities and consequently future return on investment. Moreover, investment in R&D is more financially constrained than investment in physical capital. Compared to physical capital, investment in R&D can hardly be used as collateral and is considered to contain high risk given the uncertainty of its output and problems of information asymmetry linked to it.

As to extend the explanatory factors to the reason of financially entangled R&D investment, some studies attempt to analyze the particularities of R&D to firms, especially the questions related to uncertainty of return and asymmetric information. Holmstrom (1989) invokes the question of moral hazard stem from possible agency problems and cost of contract, which is an important reason of higher marginal cost to small firms. Similar explanations are provided by Aghion and Tirole (1994) who emphasize the low certainty to realize innovation. Anton and Yao (1994) and Bhattacharya and Chiesa (1995) consider the problem of appropriation and the confidential nature of certain R&D projects as explication to high capital cost suffered by small firms.

Given the investment in R&D is financially restricted, it is logical that firms tend to use internal funds as financing resources for their R&D activities. Hall (2002) suggests that firms with high R&D investment intensity resort in low proportion to financing by debt. Brown et al. (2012) explain that firms keep cash reserves - corresponding to liquid assets - in order to smooth out volatility of R&D spending against finance shocks in short term. This point of view is corroborated by Acharya et al. (2007), Almeida et al. (2004) and Kim et al. (1998).

In conclusion, the link between financial constraints and R&D investment is closely established. The particularities of R&D activities, including the uncertainty of return and the problems related to asymmetric information, dissuade external financing resources. Hence investment in R&D activities is largely restrained from external funding. As a results, firms have to keep internal funds as chief choice to finance their R&D. As an additional point, this primary destination of internal funds compels firms to further finance their investment in physical capital through external

funding. The fact of being more dependent on bank lending for capital investment makes firms more vulnerable facing the pressure of financial constraints, which in turn impede firms' growth and their future capacity to invest in R&D. All in all, one way or another, the existence of financial constraints has a negative impact on firms' R&D investment. Our study adds to the subject a complementary view by considering firm dynamics according to their R&D investment patterns within the context of contracting macroeconomic environment.

This article is organized as follows. The next section describes the modeling. In section three we present our simulations and their results. We conclude in the last section of the paper.

2.2 Model

2.2.1 Sequence

We build a multi-agent model with firms denoted by $i = 1, 2, ...$ and discreet time $t = 1, 2, ...$ Firms produce a homogeneous good with three productive factors: capital K_{it}, labor L_{it}, and raw material and intermediary products M_{it}. The competition between firms is realized through their price p_{it}. The heterogeneity of firms is expressed in their productivity, financial situations and R&D patterns which indicate the extend of a firm's intent to invest in R&D activities, especially explorative research projects.

1. At each period, market demand to each firm depends on aggregate demand in value and the firm's relative price advantage compared to the rest of market in preceding period.

2. Each firm, by observing market demand at the beginning of period, make its production decision: define its price through estimation of marginal cost and markup level, then the desired production quantity to satisfy its market demand.

3. Based on the desired quantity of production, each firm defines its desired productive factors: capital, labor and raw material and intermediary goods. For the sake of simplicity, we assume that firms cannot disinvest in case their desired capital level is lower than the actual one.

4. Besides the decision of production, each firm makes its expenses on R&D, through self-financing capacity. The proportion of self-financing destined to R&D is predefined and idiosyncratic to each firm, as well as the percentage of expenses shared between risky and safe research activities.

5. Investment in capital is financed by self-financing or bank borrowing, where financial constraints could exercise as credit rationing. Firms suffering this constraint are limited in their capital and then production. Consequently, market demand could not be satisfied.

6. In each period, new entrants join the market when the industry is profitable. At the same time, some incumbent firms with negative equity value or too small market share have to exit from the industry.

2.2.2 Production

Firms produce with constant returns to scale through a Leontief type technology. Conventionally, for each firm i in period t the production function is as follows

$$Y_{it} = min\{K_{it}, \theta_{it} L_{it}\} \tag{2.1}$$

where Y_{it} is output, θ_{it} is labor productivity.

The firm's total cost TC_{it} is then calculated through

$$TC_{it} = r_{it}(A_{it} + B_{it}) + \delta K_{it} + w_t L_{it} + F \tag{2.2}$$

where r_{it} represents interest rate, A_{it} and B_{it} respectively denotes equity and debt value. For the sake of simplicity, as capital resources, we consider equity and debt have the identical level of cost. Firms remunerate shareholders every period via dividend distribution at the same rate as the interest rate of its debt. δ designates productive capital depreciation rate, w_t denotes wage and is assumed as exogenous. F indicates fixed costs.

Assuming that labor is abundant, we can then formulate

$$K_{it}^* = Y_{it}^*, L_{it}^* = \frac{Y_{it}^*}{\theta_{it}} \tag{2.3}$$

where Y_{it}^* represents the real production, K_{it}^* is the quantity of capital used in production. By excluding the possibility of disinvestment, in case of economic contraction, the rate of utilization of productive capacity could be lower than 100%, which means $K_{it}^* \leq K_{it}$. L_{it}^* corresponds to real quantity of labor.

Then the unit cost is

$$UC_{it} = \frac{TC_{it}}{Y_{it}} \tag{2.4}$$

Given the two financial resources of capital, we can write $K_{it} = A_{it} + B_{it}$. Based on this result, marginal cost could be written as

$$MC_{it} = r_{it} + \delta + \frac{w_t}{\theta_{it}} \tag{2.5}$$

2.2.3 Market demand

The value of aggregate demand evolves according to an exogenous growth rate g_t

$$D_t = (1 + g_t)D_{t-1} \tag{2.6}$$

Then market demand to each firm in quantity is

$$d_{it} = \frac{s_{it}D_t}{p_{it}} \tag{2.7}$$

where p_{it} indicates price and s_{it} is market share of each firm. The market share is calculated as the price of the firm relative to the average price of the market in previous period.

$$s_{it} = (\frac{s_{it-1}}{p_{it-1}})^{\lambda} / \sum_{i} (\frac{s_{it-1}}{p_{it-1}})^{\lambda} \tag{2.8}$$

the λ in the function of market share could be understood as a price elasticity of demand, it measures the sensitivity of quantity demanded by the market to the change in price, $\lambda > 0$. When $\lambda < 1$ the demand is less elastic which means the change of demand is slight compared to the change in price. When $\lambda > 1$ the demand is more responsive to any movement of price. We also introduce the market price index $\overline{P}_t$ calculated as weighted average price

$$\overline{P}_t = \frac{\sum_i p_{it} Q_{it}}{\sum_i Q_{it}} \tag{2.9}$$

where Q_{it} is the quantity sold, $Q_{it} = min\{Y_{it}, d_{it}\}$

2.2.4 Production decision

At the beginning of every period, firms observe the market demand to each of them. With the knowledge of the demand volume, a firm can determine its desired production quantity with $\hat{Y}_{it} = d_{it}$. Considering the costs of factors of production r_{it} and w_t, market demand d_{it} and productivity level θ_{it} as given.

The determination of price is realized through various modeling technics in previous research works. To list only a few examples, price could be fixed at a constant value (see e.g. Clementi and Palazzo (2010)), or around market price (see e.g. Napoletano et al. (2005)), or within a interval (see e.g. Assenza et al. (2007)), or with a fixed mark-up rate (see e.g. Dosi et al. (2010)). In the present model, a firm determines its price by adding its markup to its marginal cost.

$$p^*_{it} = (1 + \mu_{it}) MC_{it} \tag{2.10}$$

with an endogenous markup μ_{it}, which is assumed to be a function of the firm's market share in previous period

$$\mu_{it} = \mu_0 + \alpha s_{it-1}^{\beta} \tag{2.11}$$

In the equation of markup, the constant μ_0 represents the minimum markup level that a firm needs, α and β are two parameters to define the relationship between a firm's past market share and its target profit level. This mechanism is close to Dosi et al. (2010)[1]. Indirectly the mechanism is also in accordance with the argument of Campbell and Hopenhayn (2005), which emphasizes that the increase in number of competitors has a negative impact on firms' markup determination. More competitors leads to lower market share, which as a consequence decreases the desired markup of firms.

Then the desired price and production quantity are

$$p_{it}^{*} = (1 + \mu_{it})(r_{it} + \delta + w_t/\theta_{it}) \tag{2.12}$$

$$Y_{it}^{*} = \frac{s_{it} D_t}{(1 + \mu_{it})(r_{it} + \delta + w_t/\theta_{it})} \tag{2.13}$$

2.2.5 Balance sheet and investment

We consider a simplified balance sheet structure where firms finance their activities through initial equity and debt, removing the possibility of new equity issue. By ignoring the possible existence of inventory, current assets which consists of cash $\pi_{it} + \delta K_{it}$ constitutes a firm's self-financing capacity. To simplify the balance sheet, we also assume that firms always prefer to reimburse their past borrowing when they have positive self-financing capacity. As a result, a firm's debt is reduced when current assets are positive. Meanwhile, a negative debt indicates a cumulative reserve of positive self-financing capacity. This assumption could be expressed as

$$B_{it} = B_{it-1} - (\pi_{it-1} + \delta K_{it-1} - R_{it-1}) \tag{2.14}$$

[1]In their modeling a firm's markup in period t is a function of its markup value in $t-1$ and its market share in two previous periods $t-1$ and $t-2$

Because firms cannot raise external finance on the equity market, the evolution of a firm's equity A_{it} is strictly related to its past profit pi_{it-1} and expenses in R&D R_{it-1}.

$$A_{it} = A_{it-1} + \pi_{it-1} - R_{it-1} \tag{2.15}$$

In case of increasing activities where desired capital stock is rising, an investment in productive assets is necessary.

$$\hat{I_{it}} = \begin{cases} \hat{K_{it}} - (1-\delta)K_{it-1} & \text{if } \hat{K_{it}} > (1-\delta)K_{it-1} \\ 0 & \text{otherwise} \end{cases} \tag{2.16}$$

With the assumption of no new equity issue, productive capital therefore has two financing resources: reinvestment of part of self-financing capacity $\phi_{it}\pi_{it} + \delta K_{it}$ and borrowing from external financial intermediaries B_{it}, where ϕ_{it} denotes the proportion of profit destined to capital reinvestment. Following the theories of pecking order, firms always prefer internal funds than bank borrowing as financing means. In this context, we consider that firms always choose using their self-financing capacity in the first place. As a cumulative positive current assets, self-financing then could be described as follows:

$$\begin{cases} |B_{it-1}| & \text{if } B_{it-1} < 0 \\ 0 & \text{otherwise} \end{cases} \tag{2.17}$$

In case of insufficient self-financing capacity, firms have to resort to bank lending BL_{it}.

In a traditional way, the dynamics of productive capital is defined by the rhythm of depreciation and value of investment I_{it}

$$K_{it} = (1-\delta)K_{it-1} + I_{it-1} \tag{2.18}$$

2.2.6 R&D investment and productivity

Positive profit has two modes of application: reinvestment in physical capital in case of increasing desired capital or constitution of liquid assets in inverse case, and expenses in R&D activities. Each firm has a predefined proportion ϕ_{it} of profit intended for productive capital or liquid assets raising, the remainder $1-\phi_{it}$ is destined for research expenses. Following the arguments of Brown et al. (2012), we assume that R&D investment is restrained from being funded via external financial intermediaries. In other words, firms can finance their research projects only by internal resource. However, in case of negative profit, the net worth will decrease, and there will be no investment in R&D.

Pertaining to the profit investment percentage ϕ_{it}, we define its initial distribution as random, and $0 \leq \phi_{it} \leq 1$ to reflect different firm profiles with reference to investment preference: some firms prefer to invest more in physical capital to avoid potential financial constraint, some others give priority to R&D activities to preserve their future competitiveness. Using R_{it} as R&D investment value, we can settle the following expression

$$R_{it} = \begin{cases} (1-\phi_{it})(\pi_{it}+\delta K_{it}) & \text{if } \pi_{it}+\delta K_{it} > 0 \\ 0 & \text{if } \pi_{it}+\delta K_{it} \leq 0 \end{cases} \tag{2.19}$$

According to literature in the field, we can recapitulate several key points related to the evolution of productivity. First, the persistence of productivity level which means that the productivity level in each period is based on the one acquired in previous period. Second, investment in R&D activities has a real impact on the improvement of productivity. As corroborated by Savignac (2008), the positive profit realized earlier could have a positive impact later on productivity, because firms with positive profit,especially high profit level, have the possibility to invest in R&D and consequently improve their productivity. Third, some R&D activities are risky with regard to outcome. Comparing to those of "classical" research area which give regular results, the effects of highly risky research on productivity betterment could be higher or zero. In the latter case the investment in question is lost (see e.g. Fagiolo and Dosi (2003)).

Empirically, according to the stylized facts cited in Klette and Kortum (2004), firms' investment in R&D follows a geometric random walk, furthermore, there is an important persistence in R&D intensity across firms. Here again we use the concept of initial random distribution of investment preference that we developed above, which means that we set *a priori* that some firms are more willing to take the risk than the others. More precisely, we introduce another measure φ_i ($0 < \varphi_i < 1$) which represents the percentage of investment in safe R&D projects. Therefore, $1 - \varphi_i$ is the proportion of R&D investment dedicated to risky but potentially high-output research area. [2] If φ_i is close to one, that means the firm prefers to invest in traditional research projects, instead of new and risky research orientation, even if the latter could bring sometimes significantly high return; vice versa. Nonetheless, as firms know that the return of research in risky areas is more uncertain for each of them, there is no possibility to adapt a firm's decision about the proportion of investment in projects with high risks contingent upon the performance of this type of research in the past.

In the present modeling, a positive outcome of R&D effort will be translated into improvement of productivity. By recapping the conditions listed above, and peculiarly taking into account the possible effects of R&D investment, the dynamics of productivity is determined within the following equation.

$$\theta_{it} = \theta_{it-1}(1 + \upsilon^a \theta^a_{it} + \upsilon^b \theta^b_{it}) \tag{2.20}$$

where υ^a and υ^b are two parameters respectively measuring stable and risky R&D research efficiency on productivity improvement. θ^a and θ^b indicate whether the outcome of past investment in R&D is positive or zero. θ^a is drawn from a Bernoulli distribution, with its parameter $\vartheta^a_{it} = 1 - e^{-\zeta^a \varphi_i R_{it-1}}$. Similarly, θ^b follows a Bernoulli distribution, with the parameter $\vartheta^b_{it} = 1 - e^{-\zeta^b (1-\varphi_i) R_{it-1}}$. The element $\upsilon^a \theta^a_{it}$ represents the impact of investment in classical research activities on productivity improvement. Naturally, $\upsilon^b \theta^b_{it}$ is related to the return of investment in

[2] It's possible to look at this question from another angle: Dosi et al. (2010) model two types of R&D activity: innovation and imitation. The former is more risky but also has a possibility to give a high output. The latter is safer but will have low performance.

risky R&D activities.

The Bernoulli distribution in the equation allows us to establish an increasing relationship between the R&D investment value R_{it} and the effects on productivity increment. As a higher input value to Bernoulli distribution yields a higher probability of positive result, this relationship shows us that a higher amount invested could potentially lead to a higher probability of positive outcome, hence a higher improvement in terms of productivity. This relationship between investment input and potential outcome is corroborated by several empirical research works (see e.g. Griffith et al. (2004)).

2.2.7 Financial constraints

In order to incorporate financial constraints into the modeling in a simple way, we assume that firms' debt B_{it} follows a one-period renewal motion. This assumption implies that at the end of each period the debt is paid back and at the beginning of subsequent period a new debt is engaged.

We construct the mechanism of financial constraints through two channels. More exactly, the constraints are performed by varying interest rates that depend on firms' financial robustness and credit rationing that firms with high debt/assets ratio could be subjected to.

We introduce an equation in which the interest rate depends directly on a firm's financial robustness and the average of the same indicator of all firms in the market. Inspired by Napoletano et al. (2005), we design the interest rate as determined by risk-free rate r_f, average debt ratio $\overline{b_t}$ and the gap between a firm's debt ratio b_{it} and the lowest debt ratio in the industry b_t^{min}, in the following expression

$$r_{it} = r_f[1 + \rho f(\bar{b}_{t-1}) + \varrho(1-\rho)g(b_{it-1} - b_{t-1}^{min})] \tag{2.21}$$

where $b_{it} = \frac{B_{it}}{K_{it}}$. ρ fixes the proportion of two determinants of interest rate and $0 < \rho < 1$. ϱ is a credit spread coefficient, $\varrho > 0$. $f'(.) < 0$ and $g'(.) > 0$.

It is clear that interest rates play a central role in financial constraints. In line with Delli Gatti et al. (2009), we can then state that the firm's scale of production is financially constrained as it

is conditioned by its financial situation via the mechanism of interest rate determination.

A firm's desired bank lending depends on the value of its desired investment and self-financing capacity. We could enumerate this relationship in the following expression:

$$B\hat{L}_{it} = \begin{cases} \hat{I_{it}} & \text{if } B_{it-1} \geq 0 \\ \hat{I_{it}} - |B_{it-1}| & \text{if } B_{it-1} < 0 \ \textit{and} \ |B_{it-1}| < \hat{I_{it}} \\ 0 & \text{if } B_{it-1} < 0 \ \textit{and} \ |B_{it-1}| \geq \hat{I_{it}} \end{cases} \tag{2.22}$$

The other channel of financing constraints is implement related to bank loan granting. If with the objective borrowing value BL^*_{it} a firm could have exceeded the limit on solvency criterion b^{thr}_t, the credit will only be partly granted. This measure implies that the financial intermediaries try to avoid default risk by restricting the debt ratio of its client. As a consequence, knowing the combination of productive factors allowing to obtain a one-period lowest production cost, the firm has to reduce its output and accordingly other productive factors quantity.

The credit rationing works with the threshold of maximum debt ratio b^{thr}_t as a limit by which banks can finance a firm. The volume of bank lending could be restrained if the desired debt ratio goes beyond the limit. Thus the effective bank lending volume is determined in the following way:

$$BL_{it} = \begin{cases} B\hat{L}_{it} & \text{if } (B\hat{L}_{it} + B_{it-1})/\hat{K_{it}} < b^{thr}_t \\ b^{thr}_t \hat{K_{it}} - B_{it-1} & \text{otherwise} \end{cases} \tag{2.23}$$

2.2.8 Entry and exit

Similar to previous research, a modeling on firm dynamics needs an efficient mechanism of entry and exit to ensure the good functioning of market competition. Several streams exist in the literature of firm dynamics with regard to entry process. In a traditional way, an endogenous process has been applied. Proposed by Jaimovich (2007); Hopenhayn (1992), through an optimization calculation, the number of new entrant depends on industrial margin level, cost of entry of the industry and their individual productivity shock. Recent studies try to improve the pattern. Clementi and Palazzo (2010) give new entrants heterogeneous characteristics. Delli Gatti et al. (2003) introduce

a mixed model where the number of entrants is an increasing function of the number of incumbent firms, the equity value of new entrants follows a normal distribution.

Based on the literature and stylized facts with regard to new entrants' profile, we model the number of entrants N_t^e is increasing in weighted average profit rate of the industry Π_t and decreasing in cost of entry c_e.

$$N_t^e = round[\chi_t] \tag{2.24}$$

with $\chi_t \sim N(\chi_t, \sigma_{\chi_t}^2)$, and the round function $f(x) = [x]$ guarantees a integer of entrant number.

$$\chi_t = \frac{\Pi_{t-1}}{c_e}\Omega \tag{2.25}$$

In this expression, $\Pi_t = \frac{\sum_i \pi_{it} Q_{it}/K_{it}}{\sum_i Q_{it}}$, Ω is a parameter that allows to calibrate the entry rate of our simulations close to stylized facts.

Two important features of new entrants should be determined when they enter into market: productivity and size. According to stylized facts, we assume that an entrant's productivity θ_{it}^e is drawn from a log-normal distribution, with mean $\mu_{\theta_{it}^e}$ linked to incumbents' average productivity Θ_t via the parameter τ_θ and $\tau_\theta \geq 1$.

$$\theta_{it}^e \sim logN(\tau_\theta \Theta_{t-1}, \sigma_{\Theta_{t-1}}^2) \tag{2.26}$$

It is also necessary to fix a new firm's size at the entry. As a representation of size, a new entrant's output level Y_{it}^e follows a log-normal distribution and independent to their initial productivity.

$$Y_{it}^e \sim logN(\tau_Y \overline{Y}_{t-1}, \sigma_{\overline{Y}_{t-1}}^2) \tag{2.27}$$

with $\tau_Y < 1$ which means new entrants' size is smaller than the average level of incumbents.

Each new entrant's price p_{it}^e follows a zero-markup based mechanism.

$$p_{it}^{e} = MC_{it}^{e} \tag{2.28}$$

For the sake of simplicity, we determine each new entrant's market share through its output in the first period. Then it is possible to calculate the individual market share of incumbent firms. The reallocation of market share includes two dynamics. A new firm enters into the market, produces and sells its products. Meanwhile, incumbent firms get the knowledge that the market demand to their products is reduced, then they have to produce and sell less products.

A new firm's market share only depends on its initial output level. Name s_{it}^{e} as its market share, we have

$$s_{it}^{e} = \frac{p_{it}^{e} Y_{it}^{e}}{D_t} \tag{2.29}$$

Assuming that the decrease of market demand caused by the entry of new firms equally affects all incumbent firms. As a result, each existing firm's market share of demand should be

$$s_{it}^{*} = s_{it} - \frac{\sum_i s_{it}^{e}}{N_t^{i}} \tag{2.30}$$

where N_t^{i} represents the number of incumbent firms.

We establish two criteria to control firm exit. The first threshold is a minimal market share s_{min}. Firms with market share lower than this limit will be considered as too small to subsist in competition. The second one is related to equity value. Firms with negative equity value is financially bankrupt, so they have to quit the industry.

2.3 Simulation

We define first of all a set of parameters related to simulation structure and initial conditions. These parameters construct a frame to the simulation by respecting stylized facts and previous studies. The simulation starts with 300 firms and run during 1000 periods. In order to carry out

several statistical analyses with comparison between our simulation results and data from previous empirical studies, we assume in the simulations that four periods equal one year. Table 2.1 and 2.2 give respectively two lists of the parametrization. The parameters of news entrants are shown in table 2.3.

The parametrization of our simulation is mainly based on previous empirical works. For instance, parameters related to interest rates are defined in such a way that firms' interest rates are maintained within the interval roughly between 4% and 10%, according to Meeks (2012), Guntay and Hackbarth (2010) and Loncarski and Szilagyi (2012). Given the distribution of debt ratio is relatively dispersed across countries and sectors (see e.g. de Jong et al. (2011) and Egger et al. (2010)), we set in the simulation all firms' initial debt to assets ratio equals 50%, as an intermediate value among statistics on the element in question. For the case concerning the parameters related to returns on R&D investment, we determine their value to make sure that all firms may have equal probability of survival under normal economic conditions, no matter what are their intensity of investment in R&D activities.

In the simulation initially firms starts with the same productivity value and capital structure. Under the impact of financial constraints and macroeconomic conditions, firms make decisions with respect to production, investment in capital and R&D activities. The decisions taken by firms result in the heterogeneity across firms in terms of productivity and financial situation and firms' dynamics within the market competition.

We firstly run a benchmark simulation in order to verify that our modeling and its parameters allow to replicate firm dynamics in line with stylized facts. We then introduce scenarios into the simulation, with the objective to analyze the industry's evolution, especially in terms of firms survival rates with respect to their characteristics in R&D investment.

2.3.1 Benchmark simulation

In this section we realize simulations without impact of economic conditions. We primarily rely the parametrization and statistic validation on existing empirical works (for instance Bellone et al.

Description	Symbol	Value
Capital depreciation rate	δ	0.025
Risk-free interest rate	r_f	0.01
Risk premium coefficient	ρ	0.30
Interest rate spread parameter	ϱ	2
Borrowing limit	b^{thr}	100%
Cost of labor	w	1
Mark-up constant	μ_0	0.05
Mark-up parameter	α	25
Mark-up parameter	β	1
Fixed costs	F	4.0
Market share parameter	λ	1
Market share limit as exit threshold	s_{min}	0.02%
Productivity shock parameter	ϑ	0.8
Non-risky R&D productivity efficiency	υ_a	0.001
Risky R&D productivity efficiency	υ_b	0.003
Non-risky R&D investment impact	ζ_a	0.006
Risky R&D investment impact	ζ_b	0.003

Table 2.1: Structural parametrization

Description	Symbol	Value
Number of firms	N	300
Number of periods	T	1000
Aggregate demand	D_t	30000
Market share	s_{i1}	0.33%
Debt/assets ratio	b_{i1}	60%
Productivity	θ_{i1}	4

Table 2.2: Initial conditions

Description	Symbol	Value
Cost of entry	c_e	1
New entrants number parameter	Ω	300
New entrants number variance	$\sigma^2_{\chi_t}$	0.2
Productivity parameter	τ_θ	1
Productivity variance	$\sigma^2_{\Theta_{t-1}}$	0.05
Output parameter	τ_Y	0.6
Output variance	$\sigma^2_{\overline{Y}_{t-1}}$	0.1

Table 2.3: New entrants calibration

(2008), Lee and Mukoyama (2012), Bartelsman et al. (2005), Bartelsman et al. (2009) and Cooper and Haltiwanger (2006)). Through the comparison between the statistic results run within the simulation and those from empirical research in the field, we can be assured of the robustness of our modeling and the well-functioning of our programming. A validated framework then allows us to run different scenarios and analyze the evolution in terms of firm dynamics according to specific conditions.

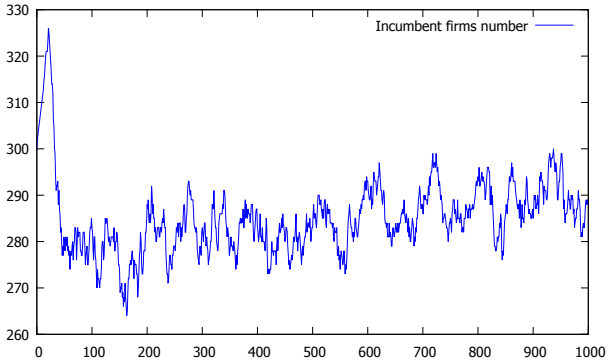
Description	Empirical data Annual	Simulation results			
		Per period		Annualized	
		Mean	Median	Mean	Median
Entry rate	6% - 10%	1.72%	1.69%	6.89%	6.76%
Exit rate	8% - 15%	1.76%	1.71%	7.03%	6.85%
Turnover rate	15% - 20%	3.49%	3.41%	13.93%	13.61%
Entrants' relative size	60%	56.93%	56.82%		
Exitors' relative size	49%	30.29%	29.91%		

Table 2.4: Reference simulation - calibration targets

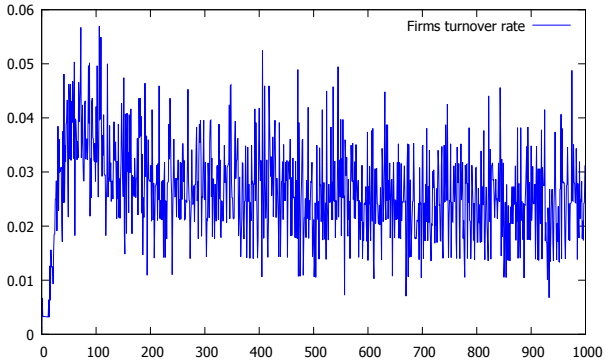
We define a set of statistics based on the simulation results. The statistics (shown in table 2.4) related to firm entry, exit and turnover rates, new entrants' and exitors' relative size compared to incumbents are roughly in line with empirical data. Meanwhile, figures 2.1(a) to 2.1(f) give the evolution of some indicators on firm dynamics during the simulation. The simulation enters rapidly into a stable state, thereafter main indicators remain relatively stable.

Graphs in figure 2.1 and figure 2.2 display some main indicators of aggregate dynamics. The number of incumbent firms and turnover rates illustrate a stationary state after the period of 200. Aggregate productivity, average price and output vary within a narrow interval, as well as the evolution of Herfindahl index, average markup and average capital return rate, which demonstrate a stable market competition condition.

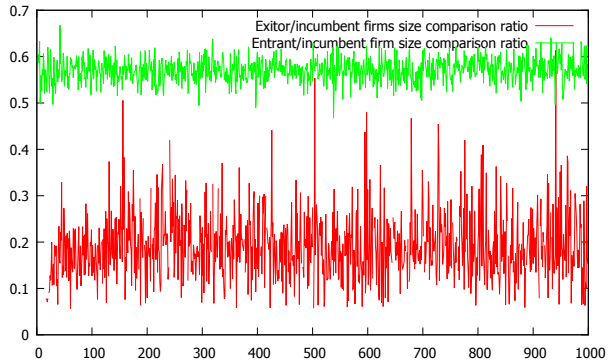
Weighted average productivity remains slightly higher than the arithmetic average one, even though both fluctuate in the same rhythm. This is due to the rising weight of relatively more productive firms in the industry. Under the effect of market selection, more efficient firms gain market share and become bigger than the rest of the firms. Consequently, the weighted average



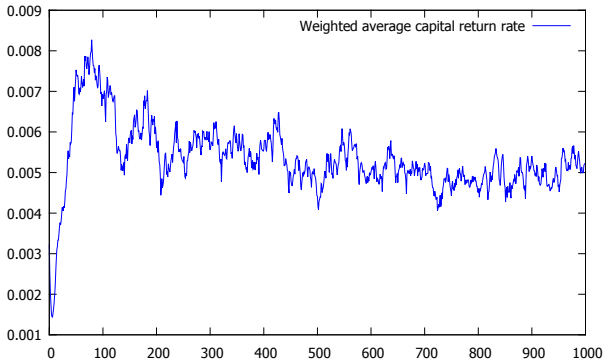
(a) Incumbent firm number



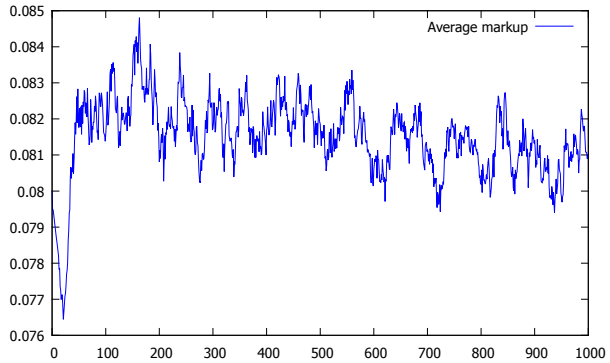
(b) Firm turnover rate



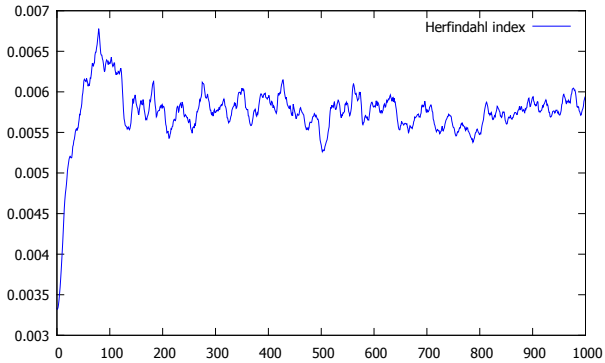
(c) Exitor, entrant and incumbent firms size comparison



(d) Weighted average capital return rate

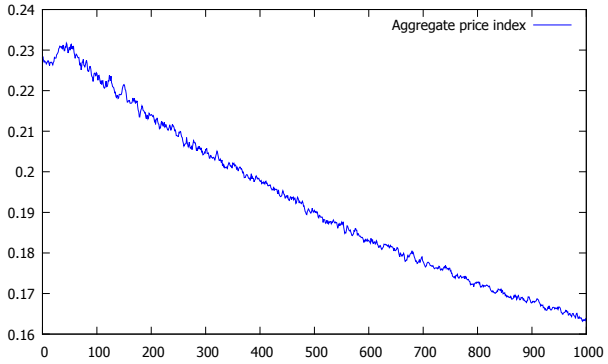


(e) Average markup

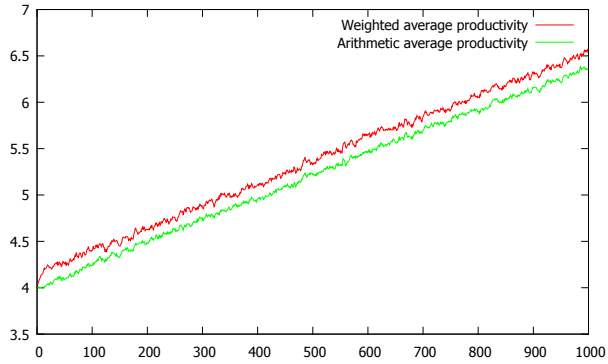


(f) Herfindahl index

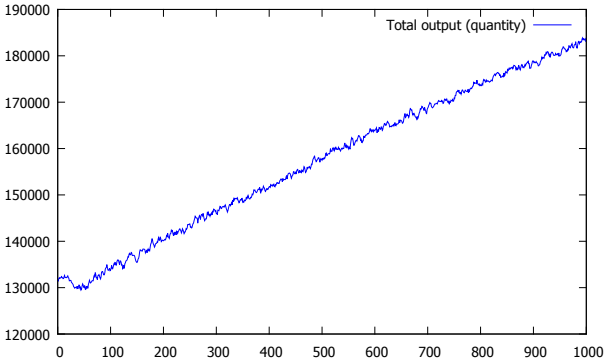
Figure 2.1: Reference simulation - aggregate dynamics



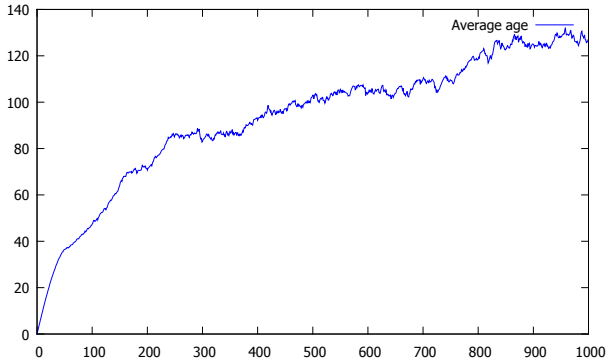
(a) Aggregate price index



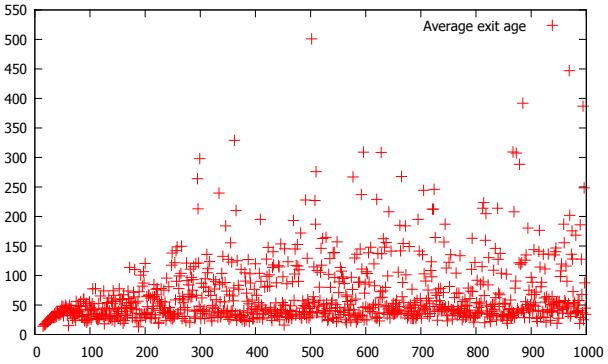
(b) Arithmetic and weighted average productivity comparison



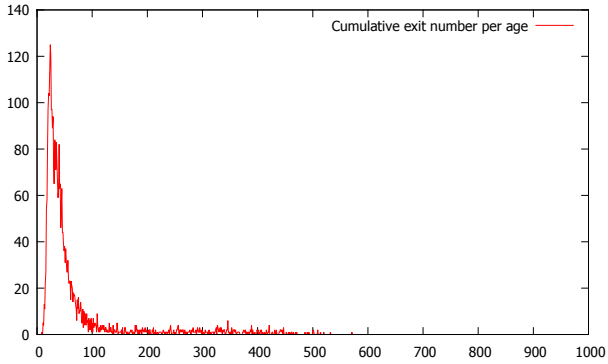
(c) Aggregate output in quantity



(d) Average age

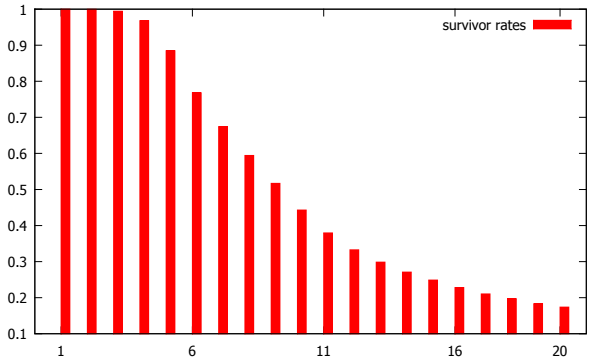


(e) Average exit age



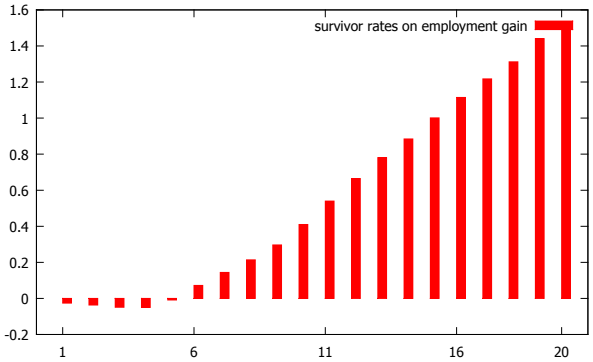
(f) Cumulative exit number per age

Figure 2.2: Reference simulation - aggregate dynamics



(a) Firm survivor rates at different lifetime

(b) Employment-based survivor rates at different lifetime



(c) Net employment gains of surviving firms at different lifetime

Figure 2.3: Reference simulation - survivor rates

level persists upper.

In line with empirical data, the graph of cumulative exit number per age shows that young firms occupy the absolute majority among those exit the market. The graph of average exit age gives the same interpretation.

Figure 2.3 presents graphs of analysis related to survivor. Compared to empirical studies (see e.g. Bartelsman et al. (2005)), our simulation results perfectly correspond with stylized facts. Firm survivor rates decreases with age, as well as the evolution of employment-based survivor rates. Net employment gains of survivors increases relatively fast during young ages then stagnates after having reached a certain size.

We introduce post entry performance to analyze firm dynamics in comparison with the industrial average and their initial state after entering the market. The tables of post entry performance

Age	θ	UC	p	b	r	K	L	K/L
1	1.00	1.00	1.00	1.33	1.11	0.58	0.58	0.96
2	1.00	1.04	1.00	1.43	1.14	0.58	0.56	1.02
3	1.00	1.09	1.01	1.55	1.18	0.57	0.55	1.10
4	1.00	1.12	1.01	1.67	1.22	0.57	0.54	1.16
5	1.00	1.11	1.01	1.75	1.25	0.58	0.55	1.12
6	1.01	1.08	1.01	1.80	1.27	0.61	0.58	1.07
7	1.01	1.06	1.01	1.84	1.29	0.65	0.62	1.04
8	1.02	1.04	1.01	1.86	1.29	0.70	0.68	1.02
9	1.02	1.01	1.00	1.85	1.29	0.75	0.73	1.00
10	1.03	0.99	1.00	1.82	1.28	0.83	0.81	0.99
11	1.03	0.98	1.00	1.77	1.27	0.91	0.89	0.98
12	1.04	0.96	1.00	1.72	1.25	0.98	0.96	0.98
13	1.04	0.95	1.00	1.66	1.23	1.05	1.03	0.98
14	1.04	0.94	1.00	1.59	1.21	1.12	1.11	0.97
15	1.04	0.94	1.00	1.52	1.19	1.17	1.16	0.97
16	1.04	0.93	1.00	1.46	1.17	1.23	1.21	0.97
17	1.04	0.93	1.00	1.40	1.14	1.29	1.27	0.97
18	1.04	0.93	1.00	1.32	1.12	1.35	1.34	0.97
19	1.04	0.92	0.99	1.23	1.09	1.41	1.40	0.96
20	1.04	0.92	1.00	1.17	1.06	1.47	1.46	0.96

Table 2.5: Reference simulation - post entry performance of firms relative to industry average

Age	θ	UC	p	b	r	K	L	K/L
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	1.00	1.03	1.00	1.07	1.03	1.00	0.98	1.05
3	1.00	1.08	1.01	1.15	1.06	0.99	0.95	1.13
4	1.00	1.11	1.01	1.23	1.09	0.99	0.93	1.19
5	1.00	1.10	1.01	1.29	1.12	1.01	0.95	1.16
6	1.01	1.08	1.01	1.34	1.14	1.04	1.00	1.11
7	1.01	1.05	1.01	1.37	1.15	1.11	1.07	1.08
8	1.02	1.03	1.01	1.39	1.16	1.19	1.16	1.05
9	1.02	1.01	1.01	1.39	1.16	1.28	1.25	1.04
10	1.03	0.99	1.00	1.37	1.15	1.40	1.37	1.03
11	1.03	0.97	1.00	1.33	1.14	1.54	1.51	1.02
12	1.04	0.96	1.00	1.30	1.13	1.65	1.62	1.02
13	1.04	0.95	1.00	1.26	1.11	1.77	1.74	1.01
14	1.04	0.94	1.00	1.20	1.09	1.92	1.90	1.01
15	1.04	0.94	1.00	1.14	1.07	2.01	1.99	1.01
16	1.04	0.93	1.00	1.10	1.05	2.08	2.06	1.01
17	1.04	0.92	1.00	1.05	1.03	2.20	2.17	1.00
18	1.04	0.92	1.00	0.99	1.00	2.31	2.28	1.00
19	1.04	0.91	1.00	0.94	0.98	2.39	2.37	1.00
20	1.04	0.91	1.00	0.89	0.96	2.49	2.47	1.00

Table 2.6: Reference simulation - post entry performance of firms relative to first year of entry

display the evolution of surviving firms through eight main indicators: productivity (θ), unit cost (UC), price (p), debt ratio (b), interest rate (r), capital (K), labor (L) and capital intensity (K/L). Table Values 2.5 shows dynamics of firms relative to industry average, the computation is carried out by comparing in each period the difference between a firm of a certain age and the sectoral mean of all firms of a different age. The following expression explains the method of calculation.

$$\chi^{ri}_{it,a} = \chi_{it,a}/\overline{\chi}_{it,b\neq a} \tag{2.31}$$

where $\chi^{ri}_{it,a}$ is the comparison of one element of firm i with age a in period t to the average of all other firms with age b which is different from a.

Equally, the calculation of values relative to first year of entry is realized by comparing for each period the main factors of survivors of a given age to the average of those just entered into the market, with the following formulation.

$$\chi^{re}_{it,a} = \chi_{it,a}/\overline{\chi}_{it,a=1} \tag{2.32}$$

Information relative to table 2.5 demonstrates a fast expansion of young firms, represented by the increase of their capital and labor value compared to industrial average. Meantime, in contrast to incumbent firms, young firms suffer higher cost of capital, accompanied by a higher debt ratio. This indicates that young firms are in general more dependent on external financing resources, given their limited size and low profitability. This situation get improved once these firms' size reaches industrial average. Moreover, surviving firms benefit from their regular progression of productivity, which leads to lower unit cost. The table 2.6 corroborates these statements by giving information about firms' performance compared to their first year after entry.

2.3.2 Deteriorating macroeconomic conditions

In this section we establish a scenario of deteriorating macroeconomic conditions, which is represented by a slump in aggregate demand. We predefine a drop in global demand of 25% in the

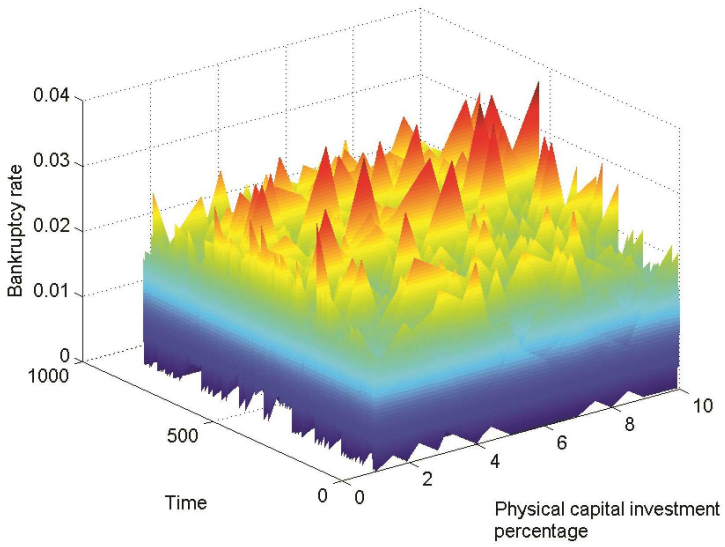


Figure 2.4: Deteriorating macroeconomic conditions - capital/R&D investment and bankruptcy

middle of simulation. We then analyze the characteristics of R&D investment - including the proportion invested in R&D activities and that in risky R&D projects - of survivors and exitors.

Figure 2.4 illustrates the relationship between exitors' capital and R&D investment patterns and their bankruptcy rates. The proportion of investment in physical capital and R&D activities is arranged in a scale of zero to ten, which indicates the percentage of investment in R&D from 0% to 100%. In other words, the value of $1 - \phi$ from zero to one. The meaning of this scale suggests when the value of ϕ is close to zero, a firm invests more in physical capital and less in R&D. It is noticeable that the sudden drop in global demand has a clear effect on firms' bankruptcy rates according to their R&D investment intensity. Compared to firms investing mainly in physical capital, firms with important innovation intensity are eliminated from market with relatively higher bankruptcy rates.

This is due to the fact that firms with high innovation intensity suffer more uncertainty of return on R&D investment. Meanwhile they are more dependent on external financing resources

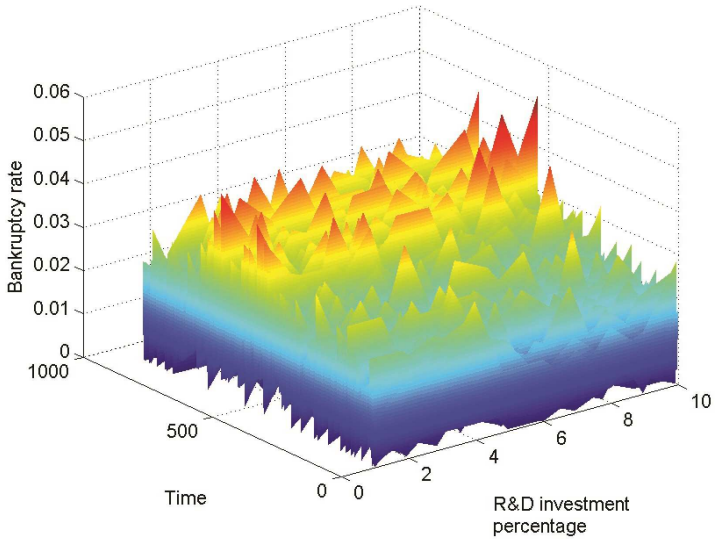


Figure 2.5: Deteriorating macroeconomic conditions - non-risky/risky R&D investment and bankruptcy

for their investment in physical capital, since their internal funds are mainly destined to R&D activities. This dependence makes these firms more vulnerable face financial constraints, in particular during periods of recession. The deterioration of macroeconomic conditions weakens firms' financial strength and increases the pressure of financial constraints on them, especially for firms with high intensity of investment in R&D. The presence of financial restrictions accelerates their exit by rising their cost of capital and imposing more credit rationing.

The relationship between firms' bankruptcy rates and their investment intensity in risky R&D projects is displayed in figure 2.5. Similarly, the intensity of investment in explorative R&D projects is sorted in a scale of zero to ten, which describes the percentage of investment in risky R&D from 0% to 100%, or corresponding to the model, the value of $1-\varphi$ from zero to one. The more the value is close to zero, the more a firm invests in non-risky R&D projects and less in risky R&D projects. It is clear that after the shock of demand, firms with high intensity of investment in risky R&D field are compelled to exit with relatively high bankruptcy rates. Consequently, investment in

explorative R&D area is disadvantaged during economic downturn. Firms with more conservative R&D investment strategies survive better the recession.

In order to study the impact of shock of demand on market structure in terms of firms' R&D investment patterns, we also group our observations in two categories: before and short term (two years) after the event and analyze the characteristics of survivors and exitors.

	Before		After	
Average	Survivors	Exitors	Survivors	Exitors
ϕ	0.52	0.49	0.84	0.21
φ	0.51	0.48	0.63	0.43
Debt ratio	51.36%	96.25%	50.17%	98.83%
Interest rates	7.21%	10.52%	7.69%	10.73%

Table 2.7: Deteriorating macroeconomic conditions - analysis of survivors and exitors

Table 2.7 list the analysis of characteristics of survivors and exitors before and after the shock of demand. The value of ϕ indicates the percentage of internal funds invested in physical capital. Accordingly, the value of $1 - \phi$ represents the R&D investment intensity of firms. φ signifies the proportion of R&D investment oriented to safe R&D projects, and $1 - \varphi$ the proportion for investment in risky R&D.

Before the shock, the average intensity of R&D investment is almost equally shared by survivors and exitors. Similar situation could be observed with regard to the average of φ. This two elements describe the case where firms' survival and exit are generally not dependent on their innovation intensity. At the same time, compared to exitors, survivors have a much better financial robustness and benefit from lower cost of capital.

After the shock of demand, revealed by the high average value of ϕ, the group of survivors is concentrated by firms with high interest to invest in physical capital. In contrast, exitors are mainly composed of firms with high innovation intensity. Among those firms who survive, within their investment in R&D the majority is destined for traditional research projects. Whereas for exitors' investment in R&D, relatively risky projects occupy a more important place. The results in this table show from another angle of view the influence of deteriorating macroeconomic conditions

on market selection according to firms' innovation intensity. The weakened financial strength due to contraction of economic environment discourages firms from investing substantially in R&D, and advantage firms with more conservative investment strategies.

	Before		After	
	Pro-R&D	Pro-risky R&D	Pro-R&D	Pro-risky R&D
Exit percentage	52.77%	53.98%	81.20%	73.68%

Table 2.8: Deteriorating macroeconomic conditions - profile of exitors

Table 2.8 gives the comparison of exitors' characteristics regarding their R&D investment intensity between two periods, namely before and after the shock of demand. We define a firm as pro-R&D if its percentage of internal financing resources destined to investment in R&D is over 50%. A firm is considered as pro-risky R&D if more than half of its investment in R&D activities is engaged in risky projects. Before the decrease in global demand, around half of the exitors are pro-R&D, among them, roughly half undertake mostly research projects in unknown field. This quasi balance indicates that in normal periods exit of firms is independent of their choice in terms of R&D investment.

After the plunge in demand, the balance does not exist any more. The majority of exitors are firms willing to invest more in R&D activities, and among those firms, more than half invest mainly in risky research area. The difference between the two contexts - before and after shock of demand - demonstrates the impact of declining aggregate demand on composition of exitors, where firms with high innovation intensity are eliminated due to their poor financial strength and their dependency on external financial resources.

Therefore, it is compelling that the presence of financial constraints and deteriorating macroeconomic conditions have important influence on market structure in terms of R&D investment patterns. Firms determined to invest proportionally more in R&D may gain an advantage in productivity in the long term. However, for short term firms with low innovation intensity could have better financial conditions, owing to uncertainty of return on R&D investment. Meanwhile, firms with high innovation intensity are more dependent on external financing resources, given the fact

that their internal funds are primarily dedicated to investment in R&D activities. Such dependency makes these firms more exposed to pressure of financial constraints, in particular during periods of economic contraction. The difference in outcome between long-term and short-term perspective of investment in R&D activities and physical capital, corresponding to higher or lower innovation intensity, becomes crucial when economic conditions are stringent. Firms with more conservative investment perspective could resist better recession because they hoard more capital which reinforces their financial strength. On the contrary, firms willing to engage more investment in R&D activities have more difficulties to weather the trough.

2.4 Conclusion

In this paper we set up an agent-based model to study the impact of presence of financial constraints and macroeconomic shocks on market structure in terms of firms' R&D investment patterns. Precisely, we analyze firm dynamics within deteriorating economic conditions, particularly regarding their characteristics relative to R&D investment: the proportion of internal funds dedicated to invest in R&D activities and explorative R&D projects. The results of simulation demonstrate that under stringent economic environment firms willing to engage more investment in R&D, especially R&D activities with high uncertainty of outcome have more chance to be eliminated from market competition.

The presence of financial restrictions leads to a discriminant financing conditions to firms. Firms with young age, small size or fragile financial situation have to suffer higher cost and frequent credit rationing. The uncertainty of outcome of R&D activities combined with stringent economic conditions weakens further pro-R&D firms' financial robustness. Consequently, R&D investment will be impeded when the economy is in doldrums. Considering firms' R&D activities is one of the most important driver of long-run growth, such distortion of market structure in terms of R&D investment patterns could induce negative impact on aggregate productivity growth in the long term, given that firms investing intensively in R&D activities have more chance to get eliminated.

Policies related to encourage investment in R&D should be adopted in longstanding perspective, especially in economic downturn, where such measures should be reinforced. Moreover, special funds destined to finance firms' R&D investments could have better effects, not only for promoting more research projects, but also to help maintain those firms in question in the industry. Even though this type of funds may have very low financial return, considering as another form of public subvention, it could provide larger boost to future economic growth.

Chapter 3

Economic stimulus, financial constraints and business cycle

Abstract

This research article aims at studying the outcome of economic stimulus regarding firm dynamics. Through an agent-based model, we simulate scenarios of increase in aggregate demand. The results suggest that a macroeconomic stimulation could lead to increase in output via surge of firms' investment. However, in a context of recession, firms benefit unequally from the stimulus. Young and small firms are disadvantaged due to their weakened financial situation under difficult economic conditions. On the contrary, big and longstanding firms may expand disproportionately.

Keywords: firm dynamics; economic stimulus; financial constraints.

3.1 Introduction

The economic recession after the financial crisis in 2008 has worldwide afflicted industrialized countries and revivified the well-established debates about the effectiveness of economic stimulus measures. A certain number of studies follow this current and try to analyze the determinants of government expenditure multiplier. In present state, several studies (see e.g. Carrillo and Poilly (2013)) suggest that the presence of financial constraints reinforces the impact of an increase in government spending on aggregate output. Moreover, research works (see e.g.Canzoneri et al. (2012)) suggest that business cycle, which means changes of macroeconomic conditions, has a significant influence on the extent of multiplier.

However, the existence of financial constraints leads to an imbalance in financing conditions across firms. If firms could benefit from a economic stimulus, it is unknown whether the benefit is enjoyed evenly. So far as we know, the subject relative to effects of economic stimulation at firm level is rarely studied. Therefore, in presence of both financial constraints and business cycle, what could be the differentiated impact of an macroeconomic stimulus on firm dynamics?

The objective of this paper is to study the effects of economic stimulation policy across firms, under two opposite backgrounds, economic expansion and recession. We build an agent-based model with heterogeneous firms evolving in discrete time. In our model firms are different in terms of productivity and financial situation. The competition between firms is realized through the pricing of a homogeneous product. In each period firms failing in market competition exit, meantime the industry is renewed by new entrants attracted by profitable perspective.

We show that an increase in global demand may stimulate economy by boosting firms' investment. The mechanism could be explained as follows: a higher aggregate demand raises capital demand and investment, hence firms' profitability get improved with increased output, which eventually ameliorates firms' financial situation. As a result, financial frictions get mitigated, which in turn supports further investment. However, within a context of recession in which firms are generally heavily indebted and the financing conditions become more severe, a stimulation through aggregate demand could have smaller effect than in the contrary case, where firms' debt ratio re-

mains mostly low and financial frictions are relatively slender. This is due to the fact that firms' financial strength are largely weakened during recession. Face an increase in investment thanks to higher market demand, firms' financing capacity is limited under the pressure of financial restrictions, which operate through increasing cost of capital and credit rationing.

However, when we scrutinize the effects of such stimulus measure at firm level, we find that in periods of recession the positive impact of an increase in global demand could be more unequal regarding firms of distinct size, age and financial robustness, compared to normal economic environment. The existence of financial constraints stresses the different financing conditions to firms, among them young and small ones often suffer more. A deteriorating economic environment weakens firms' financial situation, in particular those with low age or small size. An enfeebled balance sheet brings about more impeded investment capacity. Consequently, when the economic cycle is at the trough, the profit of an economic recovery is shared in major proportion by big or longstanding firms.

This study contributes to the literature on firm dynamics by emphasizing the aggravated inequality between firms in terms of opportunity to benefit from an economic stimulus when the economic context is stringent. Actual research works demonstrate that financial constraints and business cycle both have significant effects on the magnitude of government spending multiplier. Financial constraints affect the multiplier primarily through the impact on firms' investment capacity.

Carrillo and Poilly (2013) follow the work of Bernanke et al. (1999), also build a new Keynesian model in which asymmetric information between lenders and borrowers leads to credit fictions. By comparing two scenarios, one with financial frictions and the other without, the simulation results show that the presence of financial constraints rises significantly government-spending multiplier. Moreover, this effect is intensified by the existence of liquidity trap which means a magnified credit spread. The explanation to this intensification consists in a capital accumulation mechanism where an increase in investment raises firms' assets and hence collateral level, which then improves their financial robustness. The bettered solvency allows firms to investment more in succession.

Consequently, the existence of financial constraints and liquidity trap amplifies the mechanism, which finally conduces to a higher multiplier.

By contrasting a set of theoretical studies, including the works of Aiyagari et al. (1992), Baxter and King (1993), Ramey and Shapiro (1998), Burnside et al. (2004), Ramey (2011) and Gali et al. (2007), it is noticeable that the government spending multiplier is systematically below one within frictionless theoretical models. This conclusion, from the opposite side, confirms the magnification effect of financial restrictions on multiplier.

Business cycle could condition the multiplier through both consumption and investment channels. The two channels work via the variation of financial frictions reacting to the change of macroeconomic environment, which lead to an accelerator effect by boosting consumption or investment. According to the position of the economy within its cycle, an input of identical supplementary demand could result in a growth of aggregate output with different extent.

Canzoneri et al. (2012) develop a new Keynesian model initialized by Curdia and Woodford (2009). With the model including financial frictions between lenders and borrowers, they suggest that the presupposed counter-cyclical financial frictions make spending multiplier large during recession and modest during expansion. Such uneven effects are arisen from the mechanism in which an increase in output under economic downturn could curtail the pressure of financial frictions and boost borrowers' consumption. In turn, increased consumption and reduced financing costs allow economy to recover at a higher pace than under the background of economic expansion.

Empirically, a big number of studies aim to estimate the exact value of government spending multiplier. Among some up-to-date papers, Auerbach and Gorodnichenko (2010) conduct an analysis over US macroeconomic data during the period from 1947 to 2008. They find that fiscal multiplier in recession is much higher than in expansion (above two against below one). Similarly, Bachmann and Sims (2012) study US data of 1960-2011 and find that the spending multiplier is higher than two in the doldrums, whereas the indicator falls to smaller than unity in normal economic conditions.

To sum up, financial constraints and business cycle have significant effects on the response of

the economy face an increase in demand. The conclusion of the present research gives an insight into the effects of economic stimulus at firm level.

The rest of this paper proceeds as follows. The next section introduce the modeling. Section 3 presents calibration and baseline simulation. Section 4 discusses simulation results of predefined scenarios. Finally section 5 concludes.

3.2 Model

We build an agent-based model in which firms are heterogeneous regarding productivity and financial conditions. In our modeling, the industry evolving in discreet time $t = 1, 2, ...$, firms in this industry are denoted by $i = 1, 2, ...$ By means of capital K_{it} and labor L_{it}, firms produce and sell a homogeneous product with different prices p_{it} in a competitive market. Each period firms make their decisions in terms of production and investment by observing market demand and taking into account their financial constraints.

3.2.1 Sequence of events

1. Aggregate demand varies in value exogenously.

2. The specific market demand to each firm is a function of aggregate demand and the firm's market share, which depends on the gap between it's price and the weighted average price level of the market in previous period.

3. At the beginning of each period, firms estimate their desired turnover by observing the market demand. Based on their marginal cost in current period, each firm determines its price and deduces its production quantity.

4. To achieve the desired quantity of production, each firm has to fix its capital level (the case of disinvestment is excluded), and then the quantity of its labor.

5. With the existence of financing constraints, the firms restrained from borrowing enough funds to reach their desired assets level have to produce less than their desired quantity. Consequently the demand of market to this firm cannot be entirely satisfied.

6. At the beginning of each period, if the industry remains profitable, new firms are attracted to enter. A mechanism of market share reallocation between incumbent and new firms allows new ones to take a part of global demand, to the detriment of incumbents. Meanwhile, firms who cannot survive the market competition quit.

3.2.2 Production

Based on a Leontief type technology, firms produce with constant returns to scale. Then the production function is formulated as follows

$$Y_{it} = min\{K_{it}, \theta_{it} L_{it}\} \tag{3.1}$$

where Y_{it} is output, θ_{it} is labor productivity.

The total cost of each firm TC_{it} is then calculated as

$$TC_{it} = r_{it}(A_{it} + B_{it}) + \delta K_{it} + w_t L_{it} + F \tag{3.2}$$

where r_{it} represents interest rate, A_{it} and B_{it} are respectively equity and debt value. For the sake of simplicity, we consider capital resources from shareholders and bank lending have the same level of cost. Firms distribute dividend to shareholders as remuneration every period. δ describes productive capital depreciation rate. w_t indicates wage and is assumed as exogenous. F signifies fixed costs.

Assuming that there exists no restriction on labor supply, then we can write

$$K_{it}^* = Y_{it}^*, L_{it}^* = \frac{Y_{it}^*}{\theta_{it}} \tag{3.3}$$

where Y_{it}^* represents the real production, K_{it}^* is the quantity of capital used in production. By excluding the possibility of disinvestment, in case of economic contraction, the rate of utilization of productive capacity could be lower than 100%, in other words, $K_{it}^* \leq K_{it}$. L_{it}^* corresponds to real quantity of the other productive factor.

Then the unit cost should be

$$UC_{it} = \frac{TC_{it}}{Y_{it}} \tag{3.4}$$

We consider a simplified balance sheet structure where firms finance their productive activities with stock of equity and debt, taking off the possibility of new equity issuance. By ignoring the existence of inventory, current assets include $\pi_{it} + \delta K_{it}$ and constitute a firm's self-financing capacity. We also simplify the balance sheet by assuming that firms always prefer to reimburse their past borrowing when they have positive self-financing capacity.

$$B_{it} = B_{it-1} - (\pi_{it-1} + \delta K_{it-1}) \tag{3.5}$$

In other words, the current assets reduce debt. Hence a negative debt indicates a cumulative reserve of positive self-financing capacity. Consequently, $K_{it} = A_{it} + B_{it}$. Based on this assumption, marginal cost MC_{it} could be calculated in the following way:

$$MC_{it} = r_{it} + \delta + \frac{w_t}{\theta_{it}} \tag{3.6}$$

3.2.3 Demand

We assume the value of aggregate demand evolves with exogenous growth rate g_t

$$D_t = (1 + g_t)D_{t-1} \tag{3.7}$$

Then market demand to each firm in quantity is

$$d_{it} = \frac{s_{it} D_t}{p_{it}} \tag{3.8}$$

where p_{it} indicates price and s_{it} is market share of each firm. The market share is calculated as the price of the firm relative to the average price of the market in previous period. λ could be understood as a price elasticity of demand, it measures the sensitivity of quantity demanded by the market to the change in price, $\lambda > 0$. When $\lambda < 1$ the demand is less elastic which means the change of demand is slight compared to the change in price. When $\lambda > 1$ the demand is more responsive to any movement of price.

$$s_{it} = (\frac{s_{it-1}}{p_{it-1}})^{\lambda} / \sum_{i} (\frac{s_{it-1}}{p_{it-1}})^{\lambda} \tag{3.9}$$

We also introduce the market price index $\overline{P}_t$ calculated as weighted average price

$$\overline{P}_t = \frac{\sum_i p_{it} Q_{it}}{\sum_i Q_{it}} \tag{3.10}$$

where Q_{it} is the quantity sold, $Q_{it} = min\{Y_{it}, d_{it}\}$

The profit of each firm is logically the difference between turnover and total cost

$$\pi_{it} = p_{it} Q_{it} - TC_{it} \tag{3.11}$$

3.2.4 Production decision

We assume that firms observe the market demand to each of them at the beginning of every period. By knowing the demand volume, a firm can determine its desired production quantity with $\hat{Y}_{it} = d_{it}$. Considering the costs of production factors r_{it} and w_t, market demand d_{it} and productivity level θ_{it} as given.

Previous modeling research works employed various mechanisms to determine price. For exmaple, price could be fixed at a constant value (see e.g. Clementi and Palazzo (2010)), or around market price (see e.g. Napoletano et al. (2005)), or within a interval (see e.g. Assenza et al. (2007)),

or with a fixed mark-up rate (see e.g. Dosi et al. (2010)). In our modeling, with the knowledge of their marginal cost level, firms fix their price by adding a markup to their marginal cost.

$$p^*_{it} = (1 + \mu_{it})MC_{it} \tag{3.12}$$

where the endogenous markup μ_{it} is assumed to be a function of the firm's market share of preceding period

$$\mu_{it} = \mu_0 + \alpha s^{\beta}_{it-1} \tag{3.13}$$

In this equation, the constant μ_0 represents the minimum markup level that a firm needs, α and β are two parameters to define the relationship between a firm's past market share and its markup level. Dosi et al. (2010) applied a similar mechanism but with some difference in detail. In their modeling a firm's markup in period t is a function of its markup value in $t-1$ and its market share in two previous periods $t-1$ and $t-2$. This type of markup determination corresponds indirectly to the statement of Campbell and Hopenhayn (2005), who suggest that the increase in number of competitors has a negative impact on firms' markup determination. More competitors means lower market share, which should decrease desired markup level.

Based on above equations we can then determine the desired production volume and price

$$p^*_{it} = (1 + \mu_{it})(r_{it} + \delta + w_t/\theta_{it}) \tag{3.14}$$

$$\hat{Y_{it}} = \frac{s_{it}D_t}{(1 + \mu_{it})(r_{it} + \delta + w_t/\theta_{it})} \tag{3.15}$$

At the beginning of each period, when a firm has determined its target price p^*_{it} and output $\hat{Y_{it}}$, it defines also its decisions in terms of desired capital $\hat{K_{it}}$ and labor $\hat{L_{it}}$, depending on the output and costs of productive factors. Following our assumption, a firm can adjust its labor quantity at market wage rate without obstacle. However, if its accumulated capital is not enough compared to the target level, it has to seek recourse through external financial intermediaries, where comes

up the question of financing constraints that we will discuss in section 3.2.7.

3.2.5 Equity, debt, assets and investment

By assuming that firms cannot raise capital in equity market, the evolution of a firm's equity A_{it} is strictly related to its profit of past period, with the following expression

$$A_{it} = A_{it-1} + \pi_{it-1} \tag{3.16}$$

In case of increasing activities where desired capital becomes more important than stock, an investment in productive assets I_{it} is necessary.

$$\hat{I}_{it} = \begin{cases} \hat{K}_{it} - (1-\delta)K_{it-1} & \text{if } \hat{K}_{it} > (1-\delta)K_{it-1} \\ 0 & \text{otherwise} \end{cases} \tag{3.17}$$

Considering no possible new equity issue, productive capital therefore has two financing resources: self-financing and borrowing from external financial intermediaries. According to the theories of pecking order, firms always prefer internal funds than bank borrowing as financing resources. In this context, we assume that firms always consider using their self-financing capacity in the first place. As a cumulative positive current assets, in our modeling, self-financing is available if the debt is negative in previous period. The value of self-financing consequently could be described as follows:

$$\begin{cases} |B_{it-1}| & \text{if } B_{it-1} < 0 \\ 0 & \text{otherwise} \end{cases} \tag{3.18}$$

In case of insufficient self-financing capacity, firms have to resort to bank lending BL_{it}.

Following the traditional way, the dynamics of productive capital is defined by the rhythm of depreciation and value of investment

$$K_{it} = (1-\delta)K_{it-1} + I_{it-1} \tag{3.19}$$

3.2.6 Productivity

We introduce a simple mechanism of chocs that drive the dynamics of firms productivity. Based on its productivity level in previous period, each firm receives a periodic choc to productivity, and the choc is normally distributed. It is preferable to maintain a stable evolution of aggregate productivity in order to have a favorable environment of simulation. To achieve this objective, we introduce a constant ϑ that allows to tie the dynamics of productivity jointly to its initial and periodic values.

$$\theta_{it} = \vartheta\theta_{it-1} + (1-\vartheta)\overline{\theta}_{i0} + \epsilon_{it} \tag{3.20}$$

where $\epsilon_{it} \sim N(0, \sigma_\epsilon^2)$, $0 \leq \vartheta \leq 1$

3.2.7 Financial constraints

We assume firms follow a periodic debt renewal motion, at the end of each period the debt B_{it} is paid back and at the beginning of subsequent period a new debt is engaged.

As we point out above, financial constraints are one of the main determinants of firm dynamics. In our modeling, the constraints are presented as varying interest rates that depend on firms' financial robustness and possible credit rationing that firms with high debt/assets ratio could be subjected to.

Inspired by Napoletano et al. (2005), we define that interest rate is determined by risk-free rate r_f, average debt ratio $\overline{b_t}$ and the gap between a firm's debt ratio b_{it} and the lowest debt ratio in the industry b_t^{min}, where $b_{it} = \frac{B_{it}}{K_{it}}$.

$$r_{it} = r_f[1 + \rho f(\overline{b}_{t-1}) + \varrho(1-\rho)g(b_{it-1} - b_{t-1}^{min})] \tag{3.21}$$

where ρ fixes the proportion of two determinants of interest rate and $0 < \rho < 1$. ϱ is a credit spread coefficient, $\varrho > 0$. $f'(.) < 0$ and $g'(.) > 0$.

As a result, interest rate increases when a firm's debt ratio get higher relative to the low-

est one or firms' financial situation is deteriorated in general, or the coefficient of credit spread becomes more important. In the present model interest rate plays a central role in financial constraints. Like Delli Gatti et al. (2009), we can say that the firm's scale of production is financially constrained: it is determined by its financial situation via the interest rate calculation mechanism.

Financial constraints could also come out as credit rationing. A firm's desired bank lending depends on the value of its desired investment and its self-financing capacity. We could formulate this relationship through the following expression:

$$\hat{BL}_{it} = \begin{cases} \hat{I}_{it} & \text{if } B_{it-1} \geq 0 \\ \hat{I}_{it} - |B_{it-1}| & \text{if } B_{it-1} < 0 \ \textit{and} \ |B_{it-1}| < \hat{I}_{it} \\ 0 & \text{if } B_{it-1} < 0 \ \textit{and} \ |B_{it-1}| \geq \hat{I}_{it} \end{cases} \tag{3.22}$$

Therefore, financing constraint is set in bank loan granting: if with the objective borrowing value BL^*_{it} a firm could have exceeded the solvency limitation criterion b^{thr}_t, the credit will only be partly granted. This measure means the financial intermediaries try to avoid default risk by restricting the debt ratio of its client. As a consequence, knowing the combination of productive factors allowing to obtain a one-period lowest production cost, the firm has to reduce its output and other productive factors quantity.

In this mechanism, we introduce a threshold of maximum debt ratio b^{thr}_t as a limit according to which banks can finance a firm. The credit rationing could be involved if the desired debt ratio goes beyond the limit. The effective bank lending volume is hence determined in the following way:

$$BL_{it} = \begin{cases} \hat{BL}_{it} & \text{if } (\hat{BL}_{it} + B_{it-1})/\hat{K}_{it} < b^{thr}_t \\ b^{thr}_t \hat{K}_{it} - B_{it-1} & \text{otherwise} \end{cases} \tag{3.23}$$

3.2.8 Entry and exit

Several streams exist in the literature of firm dynamics with regard to entry process. For instance, Winter et al. (2003) introduce a stochastic mechanism in order to determine new entrants. However,

in a more traditional way, an endogenous process has been applied. Proposed by Jaimovich (2007) and Hopenhayn (1992), through an optimization calculation, the number of new entrants depends on industrial margin level, cost of entry of the industry and their individual productivity shock. Recent studies try to improve the pattern. Clementi and Palazzo (2010) give new entrants heterogeneous characteristics. Delli Gatti et al. (2003) introduce a mixed model where the number of entrants is an increasing function of the number of incumbent firms, the equity value of new entrants follows a normal distribution.

Based on the literature and stylized facts with reference to new entrants' profile, we model the number of entrants N_t^e is increasing in weighted average profit rate of the industry Π_t and decreasing in cost of entry c_e.

$$N_t^e = round[\chi_t] \tag{3.24}$$

with $\chi_t \sim N(\chi_t, \sigma_{\chi_t}^2)$, and the round function $f(x) = [x]$ guarantees a integer of entrant number. The value of χ_t is calculated directly with weighted average of capital return rate and entry cost.

$$\chi_t = \frac{\Pi_{t-1}}{c_e}\Omega \tag{3.25}$$

In this expression, $\Pi_t = \frac{\sum_i \pi_{it} Q_{it}/K_{it}}{\sum_i Q_{it}}$, Ω is a parameter that allows to calibrate the entry rate of our simulations close to stylized facts.

Two important features of new entrants should be determined when they enter into market: productivity and size. According to stylized facts, we assume an entrant's productivity θ_{it}^e is drawn from a log-normal distribution, with mean $\mu_{\theta_{it}^e}$ linked to incumbents' average productivity Θ_t via the parameter τ_θ and $\tau_\theta \geq 1$.

$$\theta_{it}^e \sim logN(\tau_\theta \Theta_{t-1}, \sigma_{\Theta_{t-1}}^2) \tag{3.26}$$

In a similar way, as a representation of size, a new entrant's output level Y_{it}^e follows a log-normal distribution and independent to their initial productivity.

$$Y_{it}^{e} \sim logN(\tau_Y \overline{Y}_{t-1}, \sigma^2_{\overline{Y}_{t-1}}) \tag{3.27}$$

with $\tau_Y < 1$, which means that the majority of new entrants' size is lower than the average level of incumbents.

Each new entrant's price p_{it}^{e} follows a zero-markup based mechanism.

$$p_{it}^{e} = MC_{it}^{e} \tag{3.28}$$

Our modeling also implies the determination of each new entrant's market share at the moment of their first appearance in the market, as well as that of incumbent firms. The reallocation of market share consists of a mechanism with two sides: a new firm enters in the market, produces and sells its products, at the same time, incumbent firms observe the market demand to their products reduce, then they produce and sell less products. Consequently, a new firm's market share depends on its initial output level. Denote s_{it}^{e} as its market share, it is computed in the following way

$$s_{it}^{e} = \frac{p_{it}^{e} Y_{it}^{e}}{D_t} \tag{3.29}$$

For the sake of simplicity, assume that the market demand decrease caused by the entry of new firms is identically charged to all incumbent firms. Then each existing firm's market share has to take into account the equative reduction.

$$s_{it}^{*} = s_{it} - \frac{\sum_i s_{it}^{e}}{N_t^i} \tag{3.30}$$

where N_t^i represents the number of incumbent firms.

Finally, regarding the side of exit, two criteria are established. The first threshold is a minimal market share s_{min}: firms with realized market share lower than this limit will be considered as too small to subsist in market competition. The second criterion relies on equity value. Firms with

equity value below zero - it is generally the case for lossmaking firms - have to quit the industry.

3.3 Simulation

In this section we in the first place determine the parameters to different variables in the models. We calibrate the models in order to make sure that they can replicate stylized facts in firm dynamics. A series of results in graphs and tables show that the baseline simulations can produce data related to the evolution of firms with characteristics respecting the facts from empirical studies. Subsequently we introduce predefined scenarios into the simulations, for the sake of testing the impact of specific macroeconomic conditions on firms.

3.3.1 Calibration

We determine a series of values in terms of structural parameters and initial conditions based on previous research works related to the subject. For example, with the knowledge of studies of Meeks (2012), Guntay and Hackbarth (2010) and Loncarski and Szilagyi (2012), we delimit the main interval of interest rates between 4% and 8%. Based on the information of de Jong et al. (2011) and Egger et al. (2010), by taking the intermediate value, we define new entrants' initial debt to assets ratio as 50 percents. The calibration of structural parameters, initial conditions and conditions of new entrants are displayed separately in table 3.1, 3.2 and 3.3.

3.3.2 Baseline simulation

The simulations initially contain 300 firms and run for 1000 periods. In the simulations under standard conditions, firms start with the same level of capital and productivity. By receiving periodic shocks, firms' productivity level varies, and in consequence their financial situation and decisions regarding investment and production, which represent the heterogeneity across firms. The mechanism of competition makes firms with lower price expand, to the disadvantage of the others. Meanwhile, new firms join the competition and some others cannot subsist leave.

Description	Symbol	Value
Capital depreciation rate	δ	0.025
Risk-free interest rate	r_f	0.01
Risk premium coefficient	ρ	0.30
Interest rate spread parameter	ϱ	2
Borrowing limit	b^{thr}	100%
Cost of labor	w	0.5
Mark-up constant	μ_0	0.04
Mark-up parameter	α	20
Mark-up parameter	β	1
Fixed costs	F	8
Market share parameter	λ	1
Market share limit as exit threshold	s_{min}	0.02%
Productivity shock parameter	ϑ	0.8

Table 3.1: Structural parameters

Description	Symbol	Value
Number of firms	N	300
Number of periods	T	1000
Aggregate demand	D_t	30000
Market share	s_{i1}	0.33%
Debt/assets ratio	b_{i1}	50%
Productivity	θ_{i1}	4.0

Table 3.2: Initial conditions

Description	Symbol	Value
Cost of entry	c_e	1
New entrants number parameter	Ω	1000
New entrants number variance	$\sigma^2_{\chi_t}$	0.2
Productivity parameter	τ_θ	1
Productivity variance	$\sigma^2_{\Theta_{t-1}}$	0.05
Output parameter	τ_Y	0.6
Output variance	$\sigma^2_{\bar{Y}_{t-1}}$	0.07

Table 3.3: New entrants parameters

We carry out in this section a baseline simulation under stable economic conditions to confirm the robustness of the modeling and simulation programming of the research. This baseline simulation also allows to adjust parameters for the objective of reproducing the dynamics of firms close to reality.

Several empirical works related to firm dynamics, including Bellone et al. (2008), Lee and Mukoyama (2012), Bartelsman et al. (2005), Bartelsman et al. (2009) and Cooper and Haltiwanger (2006) are taken as reference to establish calibration target. We then set a battery of statistics to compare with this targets.

Table 3.4 displays a comparison between the reference from empirical data and our simulation results regarding some main indicators on firm dynamics. The statistics performed from the results of simulations considers each period as one trimester. Hence the annualized data account actually for four periods. The results of entry rates, exit rates, turnover rates, new entrants' and exitors' relative size compared to incumbent firms are generally in accordance with statistics drawn from stylized facts. The annual turnover rates stay at a level close to empirical results. The size of new entrants and exitors respect also the stylized facts.

Description	Empirical data Annual	Simulation results			
		Per period		Annualized	
		Mean	Median	Mean	Median
Entry rate	6% - 10%	1.71%	1.68%	6.84%	6.72%
Exit rate	8% - 15%	1.69%	1.59%	6.77%	6.36%
Turnover rate	15% - 20%	3.39%	3.27%	13.60%	13.09%
Entrants' relative size	60%	57.39%	56.92%		
Exitors' relative size	49%	29.91%	28.67%		

Table 3.4: Baseline simulation - calibration targets

Graphs in figure 3.1 and figure 3.2 display the evolution of some main indicators of aggregate dynamics as the outcome of the baseline simulation. The number of incumbent firms and turnover rates illustrate that the simulations remain in a stationary state after the period of 200. Indicators including aggregate productivity, average price and output vary within a narrow interval, as well as the evolution of Herfindahl index, average markup and average capital return rate, which

demonstrate a stable market competition condition.

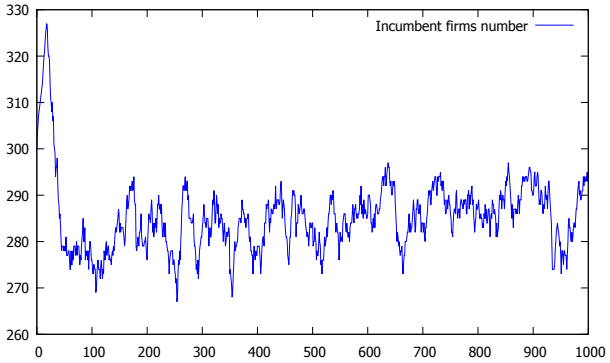
With the effects of market selection, the aggregate productivity increases progressively, which correspond to the decrease in market average price. Meanwhile, the lower price induces higher aggregate output quantity.

As another result of market competition, the weighted average productivity stays over the arithmetic average, and both vary in the same pace. The increasing weight of firms with higher efficiency in the industry leads to the superior value of weighted average. Meanwhile, new firms with productivity level potentially higher than market average enter and challenge the dominant position of relatively productive incumbents. Hence the entry of some more productive new entrants impedes dominant firms expand further, which explain the relative stable interval between weighted and arithmetic average.

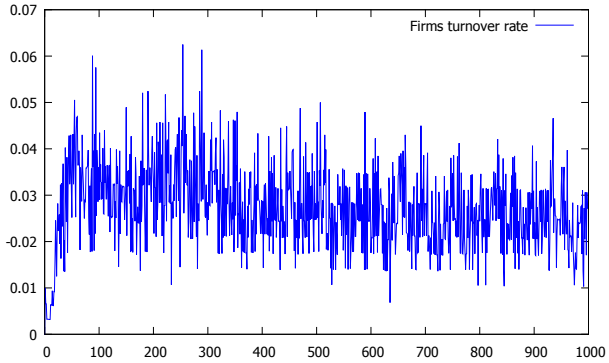
The graph of cumulative exit number per age demonstrates that young firms constitute with high percentage the firms exiting from the market. This argument is confirmed by the graph of average exit age in which exitors' age is highly concentrated at low level.

Three graphs with regard to analysis of survival rates are illustrated in Figure 3.3. The graphs display the evolution of firms' survival rates, their survival rates based on dynamics of total employment and net employment gain. In line with stylized facts from empirical studies (see e.g. Bartelsman et al. (2005)), it is noticeable that firms' survival rates decrease with age, as well as the evolution of employment-based survivor rates but with lower slope, which indicates that survivors expand in market competition. This argument is corroborated by the graph demonstrating net employment gains of survivors, which rise relatively fast during young ages then stagnates after having reached a certain size. The increase of young surviving firms explains their fast expansion in early stage, the later stagnation of longstanding firms shows the effects of market competition on firms at dominant position. Within a market competition based on price, firms trying to increase their markup and hence price will be confined to limit their growth.

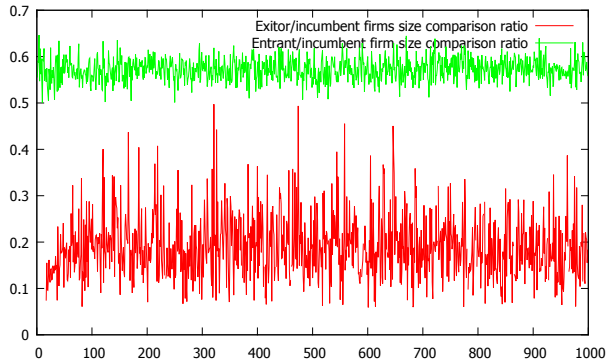
Tables 3.5 and 3.6 describe the after entry dynamics of survivors by showing the evolution of eight main indicators, namely productivity (θ), unit cost (UC), price (p), debt ratio (b), interest



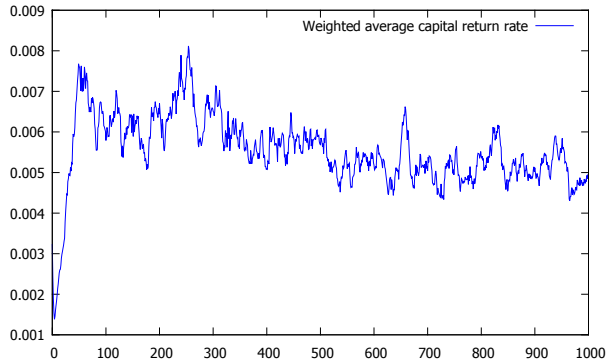
(a) Incumbent firm number



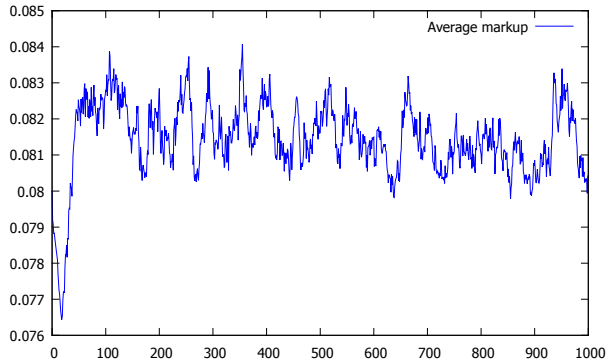
(b) Firm turnover rate



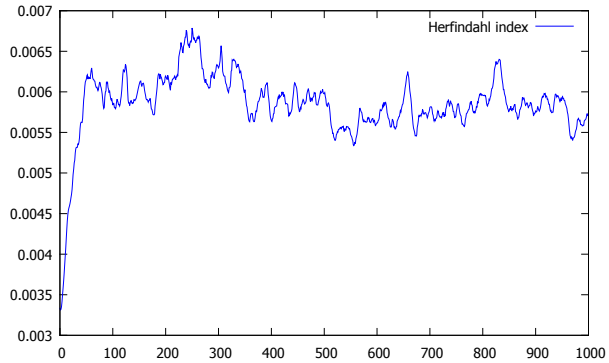
(c) Exitor, entrant and incumbent firms size comparison



(d) Weighted average capital return rate

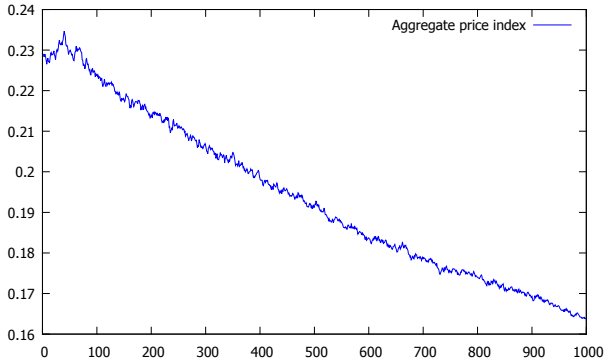


(e) Average markup

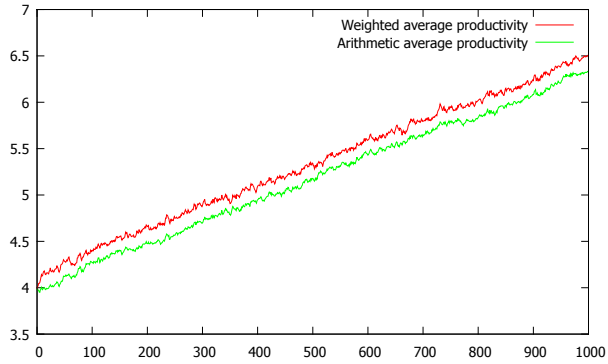


(f) Herfindahl index

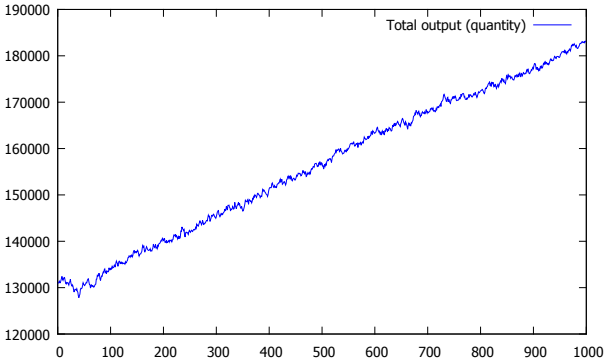
Figure 3.1: Baseline simulation - aggregate dynamics



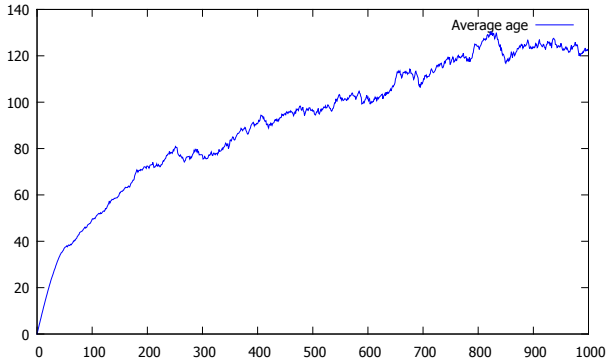
(a) Aggregate price index



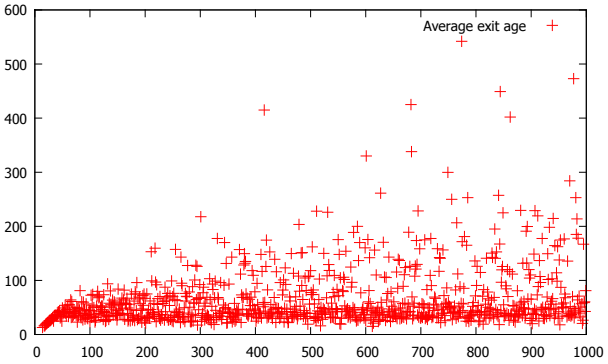
(b) Arithmetic and weighted average productivity comparison



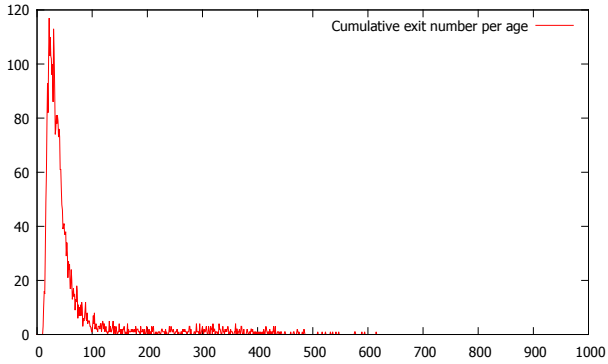
(c) Aggregate output in quantity



(d) Average age

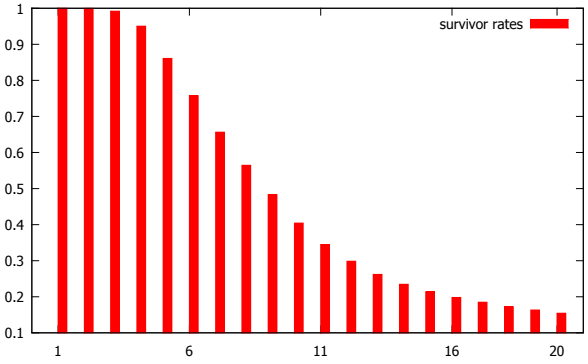


(e) Average exit age



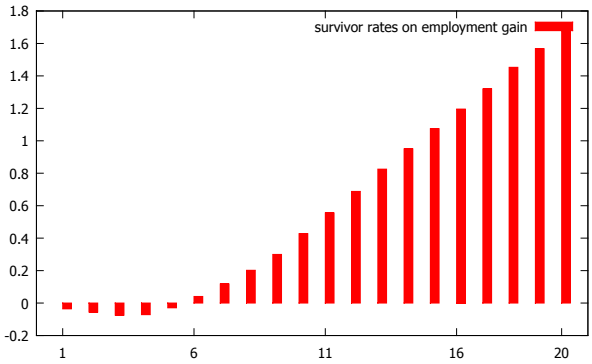
(f) Cumulative exit number per age

Figure 3.2: Baseline simulation - aggregate dynamics



(a) Firm survivor rates at different lifetime

(b) Employment-based survivor rates at different lifetime



(c) Net employment gains of surviving firms at different lifetime

Figure 3.3: Baseline simulation - survivor rates

Age	θ	UC	p	b	r	K	L	K/L
1	1.00	0.98	1.00	1.32	1.11	0.56	0.58	0.88
2	1.00	1.02	1.00	1.42	1.14	0.57	0.57	0.96
3	0.99	1.09	1.01	1.54	1.18	0.57	0.56	1.07
4	1.00	1.13	1.01	1.65	1.22	0.58	0.56	1.14
5	1.00	1.10	1.01	1.72	1.24	0.61	0.59	1.10
6	1.01	1.08	1.01	1.76	1.26	0.64	0.62	1.05
7	1.01	1.06	1.01	1.80	1.27	0.68	0.66	1.03
8	1.01	1.04	1.01	1.80	1.27	0.73	0.71	1.01
9	1.02	1.02	1.01	1.79	1.27	0.78	0.77	0.99
10	1.02	1.00	1.01	1.75	1.26	0.84	0.83	0.98
11	1.03	0.98	1.00	1.71	1.25	0.90	0.89	0.98
12	1.03	0.97	1.00	1.64	1.23	0.98	0.97	0.97
13	1.03	0.96	1.00	1.57	1.20	1.05	1.04	0.97
14	1.03	0.95	1.00	1.49	1.18	1.12	1.11	0.96
15	1.03	0.94	1.00	1.41	1.15	1.18	1.18	0.95
16	1.03	0.93	1.00	1.34	1.12	1.25	1.26	0.94
17	1.03	0.93	1.00	1.25	1.09	1.32	1.32	0.95
18	1.03	0.92	1.00	1.16	1.06	1.38	1.39	0.94
19	1.03	0.92	1.00	1.07	1.03	1.43	1.44	0.94
20	1.04	0.91	0.99	0.99	1.00	1.48	1.49	0.94

Table 3.5: Baseline simulation - post entry performance of firms, relative to industry average

rate (r), capital (K), labor (L) and capital intensity (K/L) for age from one to twenty years. Table 3.5 presents the post entry performance of firms in comparison with the industrial average. The comparison is realized by contrasting for each period the state of a firm of a certain age to the industrial average of all firms with different ages. It can be formulated as follows:

$$\chi^{ri}_{it,a} = \chi_{it,a}/\overline{\chi}_{it,b\neq a} \tag{3.31}$$

where $chi^{ri}_{it,a}$ represents the indicator of comparison for a certain age. a and b are two different ages.

Compared to industrial average, young firms gain expansion rapidly. Starting at less than 60% of industrial average, their capital and labor level reach the average 13 years after. Firms' debt ratio increase after entry, which indicates that young firms massively use external financing resources to support their investment, which makes them more vulnerable to financial constraints. This statement explains from one aspect the high bankruptcy ratio of these firms. Meanwhile, survivors' productivity get improved progressively, which explains decrease of their unit cost compared to sectoral average.

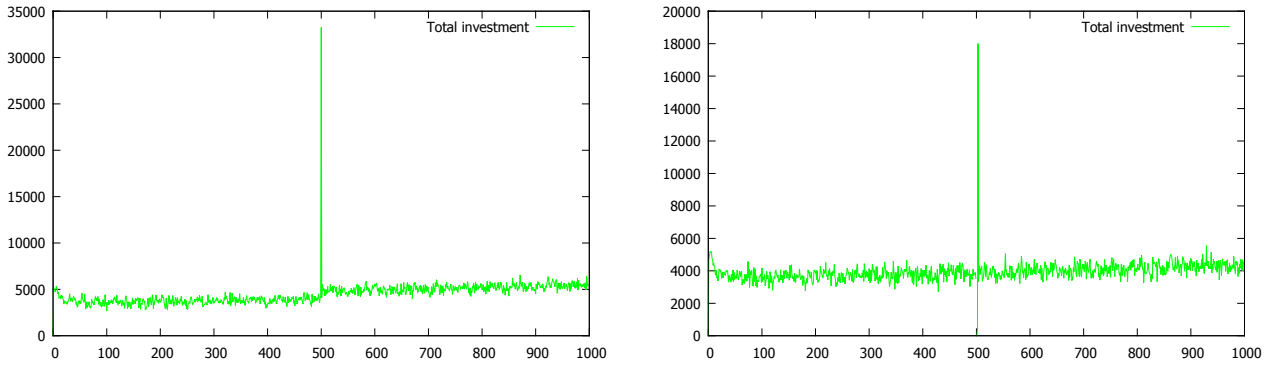
Table 3.6 presents performance of firms in comparison to their first year after entry. Expressed by the following equation, the calculation of this table is carried out by comparing for each period the main factors of survivors of a given age to the average of firms just entered into the market.

$$\chi^{re}_{it,a} = \chi_{it,a}/\overline{\chi}_{it,a=1} \tag{3.32}$$

Form the results of this table, similar observations as preceding one could be established. Represented by capital and labor, young firms expand at fast pace, accompanied by a spurt of debt ratio which implies their recourse to bank lending in order to fulfill their investment. The progression of productivity allows to reduce unit cost regularly.

Age	θ	UC	p	b	r	K	L	K/L
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	1.00	1.04	1.00	1.07	1.03	1.02	0.99	1.09
3	1.00	1.10	1.01	1.15	1.06	1.03	0.97	1.20
4	1.00	1.14	1.01	1.23	1.09	1.04	0.97	1.27
5	1.00	1.12	1.01	1.28	1.11	1.09	1.01	1.23
6	1.01	1.09	1.01	1.32	1.13	1.14	1.07	1.18
7	1.01	1.08	1.01	1.35	1.14	1.21	1.13	1.16
8	1.02	1.06	1.01	1.35	1.15	1.29	1.22	1.14
9	1.02	1.04	1.01	1.35	1.14	1.39	1.31	1.12
10	1.02	1.02	1.01	1.33	1.14	1.49	1.41	1.10
11	1.03	1.00	1.01	1.30	1.13	1.59	1.51	1.10
12	1.03	0.99	1.00	1.25	1.11	1.71	1.63	1.09
13	1.03	0.98	1.00	1.21	1.09	1.83	1.74	1.10
14	1.04	0.97	1.00	1.15	1.07	1.94	1.86	1.08
15	1.04	0.96	1.00	1.10	1.05	2.04	1.96	1.07
16	1.04	0.95	1.00	1.04	1.02	2.17	2.09	1.06
17	1.04	0.94	1.00	0.97	0.99	2.28	2.20	1.06
18	1.04	0.94	1.00	0.91	0.97	2.37	2.30	1.06
19	1.03	0.94	1.00	0.85	0.94	2.46	2.38	1.06
20	1.04	0.93	1.00	0.78	0.92	2.55	2.46	1.06

Table 3.6: Baseline simulation - post entry performance of firms, relative to first year of entry



(a) Total investment under expansion

(b) Total investment under recession

Figure 3.4: Economic stimulus - response of investment

3.3.3 Economic stimulus

In this section we perform simulations with two opposite scenarios. We establish an macroeconomic stimulation which intervenes in the middle of the simulation within two distinct backgrounds of business cycle - normal periods and economic recession. The objective of the comparison between these two scenarios is to analyze the dynamics of firms in terms of investment in front of a spurt of demand, within different macroeconomic contexts. For the first scenario, we predefine a stable macroeconomic condition in which an increase in aggregate demand of 25% arrives in period 500. This increased global demand persists till the end of the simulation as we suppose that the whole economy remains at high level after the introduction of stimulus.

The second scenario also describes a measure of increase in global demand but during periods of economic downturn. We predetermine that a slump of global demand of 25% happens in period 500. The decrease in demand provides a background of recession to the scenario. Four periods (equal one year) later the market demand regains its previous level, which represents a governmental intervention aiming at restoring economy.

Figure 3.4 illustrates the surge of aggregate investment as reaction of firms to an economic stimulation, in normal time or during economic downturn. As a response to an soar in demand, firms' investment is pumped up, in order to adjust their production to new demand. However, the extent of the surge in investment is quite distinct between two scenarios. Under normal

macroeconomic conditions, aggregate investment varies from around 4000 to more than 30000 in the short term. On the contrary, with the context of recession, the same aggregate investment only rises to more than 10000.

The explication to this large difference consists in the fact that the decrease in aggregate demand in periods of recession generally weakens firms' financial strength, which induces higher debt ratio and higher pressure from financial constraints. Facing a sudden increase in demand, firms' investment capacity is restrained due to credit rationing. As a result, aggregate investment under stringent macroeconomic conditions is impeded owing to presence of financial constraints.

Moreover, whatever the economic context, not all firms could finance their investment to the same extent. We introduce tables of deciles in order to study the evolution of concentration of firms' investment, according to their size and age. Table 3.7 gives a comparison of simulation results on size distribution between two scenarios. Table 3.8 shows the results on age distribution.

Decile	Expansion			Recession		
	Before	After ST	After MT	Before	After ST	After MT
1	0.03	0.02	0.01	0.02	0.00	0.09
2	0.33	0.78	0.53	0.37	0.28	0.53
3	1.48	2.31	2.17	1.47	0.55	1.64
4	4.04	4.44	4.51	3.96	1.46	2.64
5	7.02	6.82	6.07	6.65	5.50	5.45
6	9.19	9.41	7.32	8.80	8.41	8.19
7	11.09	11.31	12.22	11.00	8.50	9.90
8	14.60	15.95	15.71	14.97	11.53	16.15
9	20.19	17.00	21.59	20.55	18.87	22.68
10	32.05	31.96	29.87	32.21	44.90	32.73
	100.00	100.00	100.00	100.00	100.00	100.00

Table 3.7: Economic stimulus - deciles of investment along size

From table 3.7 we can observe that in normal times the distribution of firms investment along their size has clearly a increasing marginal propensity, because larger firms often invest more therefore occupy a important proportion in total investment of the industry. The other two columns give the percentage of investment short-term (up to two years) and medium-term (up to six years) after stimulus. Across the table, we can see that when economic in expansion mode an spurt

Decile	Expansion			Recession		
	Before	After ST	After MT	Before	After ST	After MT
1	7.95	5.77	6.33	7.45	7.19	5.86
2	7.24	7.32	5.47	6.43	8.76	4.69
3	6.80	7.35	6.77	6.08	3.91	6.39
4	7.28	4.42	9.32	6.27	4.84	7.09
5	9.24	6.88	8.36	8.87	7.88	8.61
6	13.66	11.77	10.28	13.98	14.30	16.16
7	16.46	15.74	12.37	18.30	24.86	19.82
8	16.55	18.61	15.65	15.16	14.83	11.83
9	10.07	16.48	15.79	11.14	7.39	12.16
10	4.75	5.67	9.66	6.31	6.04	7.38
	100.00	100.00	100.00	100.00	100.00	100.00

Table 3.8: Economic stimulus - deciles of investment along age

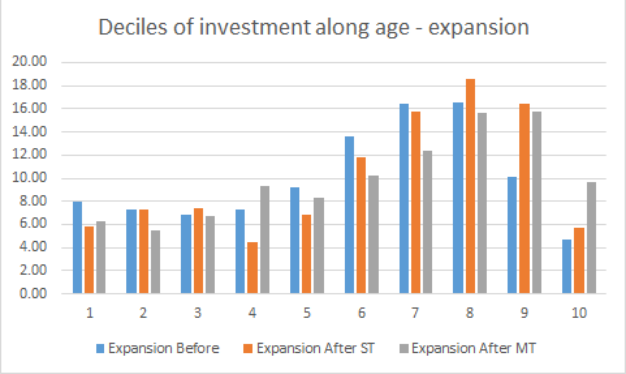
in global demand does not change the distribution of investment to a remarkable extent. Big firms always take important proportion in total investment. However, within economic slack, the situation is quite different. Short term after an restore of demand in recession, large firms benefit massively from their advantage in terms of financing capacity, hence occupy a much more substantial part in general investment. It is evident that an economic stimulus in recession gives meaningful profit to firms in dominant position.

Table 3.8 gives us another deciles of investment along firms age. Generally, firms with relatively high age invest more than young ones. As age progresses, firms surviving market competition become bigger and gain better financial situation. This pattern does not change with a stimulation policy in normal periods. When a similar measure takes place during economic downturns, longstanding firms - also larger ones - will enjoy the increase in demand and proportionally invest much more compared to the rest of the sector. Here again, young firms will not benefit from the government intervention plan in case of recession.

Graphs in figure 3.5 illustrate the comparison of deciles of aggregate investment between two scenarios. It is obvious that the inequality between small and big firms in terms of investment and expansion is aggravated under strict macroeconomic conditions. Similarly, a clear difference between two economic contexts could be remarked. The disparity between young and longstanding

(a) Deciles of investment along size

(b) Deciles of investment along size



(c) Deciles of investment along age

(d) Deciles of investment along age

Figure 3.5: Economic stimulus - deciles of investment

firms with regard to their proportion of investment at industrial level is intensified when the economic environment is more difficult.

Therefore, considered in the literature on firm dynamics as the categories of firms suffering the most impact of financial restrictions, young and small firms are also disadvantaged in front of macroeconomic stimulation, due to their financial fragility. This disadvantage is additionally intensified during periods of recession, and may impede their future growth, given the fact that longstanding and big firms are less restrained from investing and increasing their output.

3.4 Conclusion

In this study we build an agent-based model to simulate firm dynamics within a competition based on a homogeneous product. We then analyze firm dynamics within different scenarios. The results of simulations illustrate that a stimulus measure in an context of recession benefits mainly firms that have large size and survive long run market competition, to the detriment of relatively young and small firms.

The presence of this pattern is due to the existence of financial constraints and deteriorating economic conditions that reigns in recession times and precedes the measure of stimulus. Financial constraints set up a disparity across firms regarding their capacity to finance desired investment and its cost. Stringent economic conditions put all firms in a tightrope, especially firms with young age and small size. Firms with weakened financial situation have to suffer more severe financial constraints. The combination of these two factors gives birth to an uneven situation when an increase in demand arrives stem from government expenditure stimulation, in which firms with big size and old age benefit in majority from the supplementary demand.

Consequently, with regard to economic politics, it is necessary to undertake special measures aiming at tapering off financial restrictions that young and small firms face, while implementing stimulating policies in periods of recession. Specific lending funds, guaranteed lower interest rates would be compelling elements to be taken.

Conclusion

The studies performed in this thesis allow us to have a deep insight into firm dynamics taking into account presence of financial constraints and turbulence of macroeconomic conditions. In the context of competitive market, the impact of deteriorating economic environment could be larger and more persistent than expected, with regard to failure of market selection process, distortion of market structure in terms of R&D investment patterns and outcome of economic stimulus at firm level.

The failure of market selection mechanism under specific conditions reveals a plausible market inefficiency, which could have serious consequences on economy. As firms with relatively higher productivity could be forced to leave in favor of those relatively less efficient, the resource allocation becomes inefficient. Through impacting the productivity dynamics at firm level, this inefficiency may weaken aggregate productivity improvement.

At the same time, the discouragement of R&D investment due to the elimination of firms in large proportion with high innovation intensity could also alter evolution of aggregate productivity. The aggravated inequality between firms facing an macroeconomic stimulation during periods of downturn might finally influence the functioning of market selection then dynamics of firms' productivity. As a consequence, the combination of financial constraints and fluctuations of macroeconomic conditions may affect long-run economic growth with a weaker progression of aggregate productivity.

As reclaimed by previous literature on firm dynamics, it is necessary to introduce economic policies aiming at easing young and small firms' access to financing resources. However, the conclusion

of this thesis demonstrate that these policies should be further reinforced when macroeconomic environment is difficult. Meanwhile, measures with objective to encourage firms' R&D investment also should be inclined to advantage young and small firms, in order to reduce the risk of bankruptcy due to their financial fragility.

Following the theoretical works accomplished in this thesis, more empirical studies should be carried out, in order to confirm the results presented in the thesis, or on the contrary, contradict the actual arguments.

In addition, the present modeling, having already proved its stability and robustness via a large number of simulations, provides further possibility to set up more complex economic system, which may offer opportunities to study various research subjects.

One of the possible future research directions is to study effects of fluctuations in various elements of macroeconomic conditions on firm dynamics. The oil shocks in the 1970s have left indelible memory to world economy. Several studies exist in literature aiming at analyzing the impact of sudden increase in oil price on economy. For example, Blinder (1981) studies the monetary accommodation of supply shocks by integrating rational expectations and suggests that the anticipation to future oil shocks has important impact on economic dynamics. Within a context of unanticipated oil shocks there could exist an exploitable inflation-employment tradeoff, on the contrary to the case with rationally anticipated oil shocks where the economic outcome is more variable according to model specifics.

In a more recent study, Dissou (2010) stress the transmission mechanism via which increase in oil prices could influence economy. He argues that oil price shocks might have positive effects on economic growth and improve resource allocation which leads to inequalities in sectoral adjustments. Regarding the theme of this thesis, it is interesting to analyze the effects that an spurt in price of raw materials could have on firm dynamics, in presence of financial constraints and macroeconomic fluctuations.

Another potential extension to the present research framework is to consider firm dynamics within the context of open economy. A large body of research focuses on this issue. For in-

stance, Arkolakis (2010) considers firm dynamics in market competition by introducing a new entry costs theory, which is compatible with stylized facts with reference to the positive relationship between firms' entry and size in presence of a large number of exporters.

In the theoretical work, Atkeson and Burstein (2010) emphasize the counteracting effects of firm dynamics to long-term trade liberalizations, and the countervailing effects of changes in firms' decisions about entry, innovation, export and exit on aggregate productivity and welfare. With knowledge to previous studies, incorporating factors of international trade gives possibilities to study firm dynamics from a new angle of research, especially with consideration of financial imperfections.

Moreover, as mentioned in preceding section, agent-based models allow to study various subjects with the existence of economic disequilibrium. Among major conclusions in modern economics, a large proportion are realized through theoretical studies with modeling assuming equilibrium in all markets. The introduction of disequilibrium provides great opportunities to reconsider those statements from a completely new point of view.

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Résumé détaillé

En 1930, quand l'économie mondiale s'effondrait pendant la grande récession, John Maynard Keynes a écrit dans son essai intitulé « The Great Slump of 1930 », que « ... nous nous sommes impliqués dans un désordre colossal, en commettant des erreurs sur le contrôle d'une machine sophistiquée, dont nous ignorons le fonctionnement. La conséquence est que notre chance de prospérité pourrait être perdue pour un certain temps – peut-être longtemps. » Depuis, quatre-vingt-trois ans sont passés, mais son appréciation convient encore à la récession actuelle commencée après la faillite de Lehman Brothers. Cinq ans après la crise, l'économie mondiale a toujours du mal à retrouver son sentier de croissance normal. Bien qu'un grand nombre d'études aient été achevées depuis les années 1930, beaucoup reste à faire pour comprendre comment notre économie fonctionne avec un environnement financier foisonnant de plus en plus de perturbations.

Suite à l'éclatement des bulles dans le marché immobilier et des produits dérivés de crédit, la crise financière en 2008 a transmis rapidement la contraction du secteur financier à l'économie réelle, et finalement conduit à une récession globale. Cette transmission de la crise est réalisée en partie par la détérioration des conditions de financement des firmes, tel que la hausse du coût de capital à cause du sursaut des différentiels de taux de crédit, et la pénurie des sources de financement en raison du rationnement de crédit en hausse.

La contagion à travers les secteurs démontre l'influence profonde des imperfections du marché de crédit sur l'économie en perturbant son fonctionnement au niveau des firmes, qui révèle les questions concernant la dynamique de ces dernières. En plus, d'un point de vue industriel, en analysant la dynamique des firmes, qui consiste en leur entrée, croissance, survie et sortie, les

effets d'une contraction financière sur l'économie réelle également dévoilent les problématiques liées à l'efficience du marché. En d'autres termes, les observations sur le développement de la dernière crise financière et la récession suscitent la question concernant l'impact des imperfections financières sur la dynamique des firmes et l'efficience du marché.

Cette thèse contribue à la littérature en dynamique des firmes et en efficience du marché, par la démonstration d'une défaillance plausible du mécanisme de sélection de marché due à la présence des contraintes financières et des conditions macroéconomiques détériorées, qui pourraient aussi mener à une distorsion de la structure du marché en termes de modes d'investissement en Recherche et Développement (R&D) et une disparité intensifiée entre des firmes pour ce qui est de l'opportunité de bénéficier d'une éventuelle relance économique.

Thème général

L'efficience du marché est l'une des plus importantes conceptions de l'économie moderne. Par définition, un marché est considéré efficient quand l'allocation des ressources maximise le surplus total reçu par tous les membres du marché. L'efficience d'allocation invoque le fait que les ressources sont allouées selon le niveau de productivité des firmes dans le marché. Evidemment, la notion de l'efficience du marché implique l'hypothèse majeure de la compétition pure et parfaite. Quand un marché est parfaitement compétitif, la productivité est l'unique critère de sélection, qui signifie que seulement les firmes les plus compétitives peuvent survivre dans la compétition, les autres firmes doivent quitter le marché. Autrement dit, la compétition pure et parfaite indique que le mécanisme de sélection de marché fonctionne correctement.

Au-delà de l'efficience statique qui correspond à la maximisation du surplus total, un courant de recherche (voir par exemple Jovanovic, 1982 et Hopenhayn, 1992) étudie l'efficience dynamique en focalisant sur la dynamique des firmes dans un contexte de sélection de marché. Suivant cette direction, de nombreuses études essaient d'analyser le problème de compétition de marché en présence de différentes imperfections. Par exemple, Bisin et Gottardi (1999) étudient les équilibres

compétitifs en mettant l'accent sur les questions au sujet de l'asymétrie d'information.

Comme ce qui est révélé par la crise de « subprime », les imperfections financières peuvent également constituer les éléments qui pourraient interférer avec la sélection de marché. Beaucoup d'études montrent des effets crédibles des frictions financières sur la dynamique des firmes. Bernanke et al. (1999) soulignent l'influence de la situation financière des firmes sur leur investissement et leur production. Holmstrom et Tirole (1997) mettent en évidence l'impact de la solidité de bilan des intermédiaires financiers sur les activités des firmes. Effectivement, ces problèmes liés à la robustesse financière des firmes et des intermédiaires financiers relèvent la question par rapport aux contraintes financières, par le biais des difficultés que les firmes font face pour accéder aux ressources de financement externes.

Par conséquent, dans quelle mesure fonctionne le mécanisme de sélection de marché en présence des contraintes financières ? Un grand nombre d'études empiriques existent à propos de ce sujet. La plupart des recherches confirment que les mécanismes de sélection de marché fonctionnent avec différents degrés d'efficience (voir par exemple Bellone et al., 2006). Cependant, nous connaissons encore peu sur le fonctionnement du processus de sélection de marché sous des conditions macroéconomiques fluctuantes.

La récession débutée en 2009 avec simultanément des restrictions financières intensifiées a démontré une influence profonde sur les firmes. Il est évident que les changements dans l'environnement macroéconomique aussi jouent un rôle sur les effets des contraintes financières que les firmes subissent. Cette relation implique en même temps deux facteurs, l'un vient du domaine macroéconomique, l'autre de la sphère microéconomique. Néanmoins, jusqu'à ce jour peu d'études ont été effectuées afin d'analyser la dynamique des firmes sous l'impact des deux facteurs.

Le fonctionnement des mécanismes de sélection de marché avec la présence de contraintes financières et de fluctuations macroéconomiques présente une perspicacité aux effets structurels des variations conjoncturelles des conditions macroéconomiques sur l'efficience du marché. Ce point de vue est relativement innovateur comparé à la littérature traditionnelle qui étudie essentiellement l'impact des changements de la structure de marché sur les fluctuations macroéconomiques (voir

par exemple Etro et Colciago, 2010).

Toutefois, au-delà de l'analyse des effets de variations conjoncturelles sur la structure de marché, il est également nécessaire d'étudier les effets sur la croissance économique à long terme que cet impact sur la structure de marché pourrait avoir. Comme il est largement accepté que les activités de R&D et d'innovation sont un des moteurs clés de la croissance économique à long terme, incorporer les éléments d'activités de R&D dans l'étude de processus de sélection de marché nous permet d'avoir une perspective sur la dynamique des firmes et la croissance économique. Dans la littérature, un nombre important de travaux de recherche démontre que l'investissement des firmes en R&D et en innovation comme un déterminant primordial de la croissance économique. Par exemple, Dosi et al. (2010) mettent en exergue l'importance du moteur schumpétérien - l'innovation endogène au niveau des firmes – à la croissance économique à long terme.

La situation de contraction économique est souvent suivie par une intervention gouvernementale menant à une relance économique. Ce type de politiques économiques, principalement consiste en une hausse des dépenses publiques, représente une autre forme de changement des conditions macroéconomiques dans un contexte difficile. De nombreuses études, généralement d'un point de vue macroéconomique, ont analysé le mécanisme de transmission et le résultat d'une augmentation des dépenses publiques. Parmi ces travaux, les questions liées à la valeur du multiplicateur fiscal ont été mises dans une position capitale. En revanche, la combinaison spécifique des déterminants – contraintes financières, environnement économique en déclin et une augmentation rapide de la demande globale – a rarement été étudié sous l'aspect de la dynamique des firmes.

Cette thèse étudie l'impact des contraintes financières et des fluctuations macroéconomiques sur la dynamique des firmes, et ce que cet impact pourrait révéler en termes du mécanisme de sélection de marché, des modes d'investissement des firmes en R&D et des retombées d'une mesure de relance économique.

Dans un souci de clarté, nous introduisons les définitions des deux déterminants principaux dans le thème général de cette thèse. Dans la littérature, il existe de différentes définitions au sujet des contraintes financières. Par exemple, Kaplan et Zingales (1997) considèrent que les

contraintes financières peuvent être identifiées comme l'écart des coûts de financement entre les sources internes et externes. Silva et Carreira (2012) caractérisent l'existence des contraintes financières par la présence du rationnement de crédit. Delli Gatti et al. (2009) estiment que les contraintes financières sont représentées par des taux d'intérêt variables qui dépendent de la robustesse financière des firmes. Basé sur les définitions des études existantes, dans cette thèse les contraintes financières sont définies comme les restrictions que les firmes subissent lors de l'accès aux prêts des intermédiaires financiers externes, qui sont exprimées dans la modélisation par des taux d'intérêt variables dépendant de la situation financière des firmes et potentiellement le rationnement de crédit au cas où les firmes deviennent insolvables.

Etant donné que les études menées dans cette thèse prennent en considération les changements conjoncturels des conditions macroéconomiques comme le deuxième déterminant du fonctionnement du mécanisme de sélection de marché, il est préférable de focaliser sur la variable de la demande globale comme l'élément représentatif qui peut clairement être caractéristique de l'influence de l'environnement macroéconomique sur la dynamique des firmes.

Questions de recherche

Après le thème général, dans cette section nous présentons les trois questions de recherche qui conduisent aux trois chapitres de la thèse.

Première question

Plusieurs études ont analysé le fonctionnement du mécanisme de sélection de marché sous des conditions macroéconomiques rigoureuses. Dans leur travaux théoriques, Caballero et Hammour (1994) soulignent l'effet de « cleansing » par lequel le processus de sélection de marché est renforcé pendant les périodes de récession, où les firmes avec faible productivité sont forcées de quitter le marché, celles avec de meilleure performance productive restent dans l'industrie. En conséquence, les conditions économiques difficiles ont des effets positifs sur le mécanisme de sélection de marché.

Pourtant il existe un contre-exemple. L'étude empirique menée par Nishimura et al. (2005) a obtenu une conclusion contraire. Basé sur les données des firmes japonaises, ils ont prouvé que le mécanisme de sélection n'avait pas fonctionné comme attendu pendant la récession de 1996 à 1997. La défaillance du processus de sélection est considérée comme un facteur explicatif principal à la baisse de la productivité agrégée du pays après 1996.

La contradiction entre les conclusions des deux études révèle le débat sur les effets de l'environnement macroéconomique détérioré sur le fonctionnement du mécanisme de sélection de marché. Bien que basé sur les preuves des travaux de recherche antérieurs on puisse confirmer l'efficience du mécanisme de sélection de marché en présence des imperfections financières, cet argument ne peut qu'être validé sous des conditions économiques normales. A ce jour il n'y a pas d'affirmation claire sur le sujet dans le cas où l'environnement économique est sévère. Ainsi, ma première question de recherche est la suivante : quels sont les effets des contraintes financières sur le mécanisme de sélection de marché sous des conditions macroéconomiques draconiennes ?

Deuxième question

Un autre courant de recherche focalise sur le lien entre les contraintes financières et l'investissement des firmes en R&D. Parmi ces travaux, un grand nombre d'études empiriques analyse l'impact des contraintes financières sur les activités de R&D des firmes. Hyytinen et Toivanen (2005) analysent les données des firmes finlandaises et ont trouvé que les imperfections du marché de capital peuvent entraver l'innovation des firmes ainsi leur croissance. Avec un objectif similaire, des travaux basés sur des données de firmes de différents pays, comme Canepa et Stoneman (2008) pour le Royaume-Uni, Savignac (2008) pour la France et Mohnen et al. (2008) pour les Pays-Bas arrivent à la conclusion que l'impact des contraintes financières est en général significatif pour les petites firmes et les secteurs de haute technologie. En plus, les barrières financières à l'innovation que les firmes endurent sont représentées par à la fois le coût et la disponibilité des sources de financement.

Autres études théoriques essaient de comprendre pourquoi l'investissement des firmes en R&D peut être restreint. Hyytinen et Toivanen (2005) introduisent un cadre théorique afin d'expliquer l'impact des imperfections du marché de capital sur les activités de R&D des firmes ainsi leur croissance. Ils démontrent que les imperfections financières entraînent en même temps deux situations contradictoires par rapport à l'expansion des firmes : une fonction croissante du coût marginal de capital et une fonction décroissante des taux de rendement marginal d'investissement en R&D. La pente croissante du coût marginal de capital le long de l'investissement en R&D indique que les firmes, particulièrement celles avec taille limitée, sont plus restreintes dans leur investissement en R&D, si elles sont plus dépendantes des sources de financement externes.

Hall (2002) argumente qu'en comparant aux autres firmes, le coût marginal de capital des petites firmes ont une pente plus forte pour un niveau d'investissement en R&D donné. Ceci est à cause de l'incertitude du résultat des activités de R&D ainsi leur rendement d'investissement à l'avenir. Par ailleurs, contrairement à l'investissement en capital physique, l'investissement en R&D est financièrement plus contraint car il est difficilement utilisable comme garantie et considéré comme très risqué, étant donné l'incertitude de rendement et les problèmes d'asymétrie informationnelle qui sont liés à ce type d'investissement.

Plusieurs études essayant de comprendre pourquoi l'investissement en R&D peut être financièrement limité mettent l'accent sur les particularités des activités de R&D. Holmstrom (1989) souligne la question d'aléa moral liée aux problèmes principal-agent et les coûts de contrat, qui pourrait conduire à un coût marginal plus élevé pour les petites firmes. Aghion et Tirole (1994) mettent en évidence la forte incertitude dans le processus de réalisation d'innovation. Anton et Yao (1994), Bhattacharya et Chiesa (1995) considèrent le problème d'appropriation et la nature confidentielle de certains projets de R&D comme facteurs explicatifs au coût de capital important que les petites firmes doivent subir.

Ainsi, la pression des contraintes financières sur l'investissement en R&D pousse les firmes à chercher des sources de financement plutôt dans les fonds internes, au lieu des intermédiaires financiers externes. Hall (2002) explique que les firmes avec haute intensité d'investissement en

R&D sont en faible proportion financées par la dette. Brown et al. (2012) affirme que les firmes gardent leur réserve de liquidité afin de lisser la volatilité des dépenses en R&D contre les chocs de financement à court terme. D'ailleurs, les études d'Acharya et al. (2007), Almeida et al. (2004), et Kim et al. (1998) partagent le même point de vue.

Il est notable que les particularités des activités de R&D, surtout l'incertitude sur le résultat et les problèmes liés à l'asymétrie informationnelle entraînent le fait que l'investissement des firmes en R&D souffre des contraintes financières, qui les forcent à utiliser essentiellement leurs fonds internes comme sources de financement. Par conséquent, l'investissement en capital physique devient plus dépendant des sources externes quand les firmes engagent des dépenses en R&D lourdes. Ceci rend les firmes plus vulnérables vis-à-vis les contraintes financières.

En outre, les conditions de financement de plus en plus sévères pendant la récente récession montrent l'impact que les fluctuations macroéconomiques pourraient avoir sur les firmes à travers à la fois la contraction de demande et la raréfaction des sources de financement. Les firmes investissant massivement en R&D pourraient souffrir plus cet impact en raison de leur dépendance des sources de financement externes. En prenant en compte ce fait, ma deuxième question de recherche est : étant donnée l'hétérogénéité des firmes en termes de l'intensité d'innovation, quels pourraient être les effets de contraintes financières combinées avec un environnement macroéconomique contracté sur la probabilité de survie des firmes ?

Troisième question

Ayant voulu évaluer les effets d'une politique de relance, en particulier une hausse des dépenses publiques, un nombre important de travaux de recherche tentent d'estimer la valeur du multiplicateur, qui mesure le ratio d'un changement de production entraîné par une augmentation de demande. Le mécanisme de transmission d'une hausse de la demande globale à la croissance de la production agrégée peut fonctionner par la stimulation de consommation ou d'investissement.

Néanmoins, la présence des contraintes financières pourrait altérer les effets d'une relance économique par son influence sur la capacité des firmes à investir. En opposant deux scénar-

ios de simulation, l'un avec des frictions financières et l'autre sans les restrictions, Carrillo et Poilly (2013) démontrent que les restrictions financières renforcent les effets d'une augmentation des dépenses publiques sur la production. L'amplification de l'effet de multiplicateur est due à un mécanisme d'accumulation de capital, qui signifie le processus dans lequel un accroissement d'investissement qui résulte d'une demande supplémentaire peut engendrer une expansion de capital et une amélioration de solvabilité des firmes. En suite, la situation financière consolidée à son tour permet les firmes d'engager plus d'investissement et finalement d'accroître la production agrégée.

En même temps, plusieurs études théoriques avec une modélisation de l'environnement économique sans imperfections financières, comme Aiyagari et al. (1992), Baxter et King (1993), Ramey et Shapiro (1998), Burnside et al. (2004), Ramey (2011) et Gali et al. (2007) trouvent que la valeur du multiplicateur est inférieure à un. D'où cette conclusion, dans le sens contraire, confirme l'effet d'amplification que les contraintes financières pourraient avoir sur le résultat d'une relance économique.

En tant qu'un autre facteur explicatif, le cycle économique est aussi prouvé qu'il pourrait avoir une influence sur l'échelle du multiplicateur fiscal. Canzoneri et al. (2012) développe un modèle nouveau keynésien initié par les travaux de Curdia et Woodford (2009). Avec un modèle contenant des frictions financières entre les prêteurs et les emprunteurs de crédit, ils argumentent que les frictions financières présupposées contra-cycliques rendent le multiplicateur de dépenses publiques fort pendant la récession et modéré pendant l'expansion. Ces effets déséquilibrés sont issus du mécanisme dans lequel une augmentation de production pendant la récession pourrait atténuer la pression des contraintes financières et encourager la consommation des emprunteurs de crédit. Successivement, la consommation plus élevée et les coûts de financement réduits permettent à l'économie de reprendre à un rythme plus rapide que dans un contexte d'expansion.

En résumé, les contraintes financières et le cycle économique ont tous une influence significative sur la réaction de l'économie aux politiques de relance. Tout de même, l'existence des contraintes financières entraîne une disparité en termes de conditions de financement parmi les firmes. Si les

firmes peuvent bénéficier d'un accroissement de la demande globale en augmentant leur investissement, il n'est pas clair si cela est fait de façon égale. Jusqu'à ce jour, ce sujet a été rarement étudié. Ainsi, ma troisième question de recherche est : en présence des contraintes financières et du cycle économique, quel pourrait être l'impact différentié d'une relance économique sur la dynamique des firmes ?

Méthode de recherche

Afin de répondre aux trois questions posées ci-dessus, j'effectue trois études théoriques avec modélisation et simulation. Ce choix est motivé par les avantages et la pertinence de cette méthode par rapport au thème de recherche. La combinaison de modélisation et de simulation offre la possibilité d'étudier l'impact des facteurs spécifiques sur la dynamique des firmes en introduisant différents scénarios dans les simulations.

Cette thèse suit le courant de l'économie évolutionniste. Comme mentionné précédemment, le centre de la thèse s'appuie sur le fonctionnement du mécanisme de sélection de marché. Pour valider si le mécanisme fonctionne correctement dans les simulations, il est nécessaire de distinguer les firmes selon leur niveau de productivité. En même temps, un des déterminants clés dans la thèse – la présence des contraintes financières – indique l'existence d'une différence concernant la situation financière des firmes et leurs conditions de financement. La particularité de la double différentiation demande une méthode de modélisation par laquelle on peut prendre en compte l'hétérogénéité des firmes en termes de productivité et de situation financière. En conséquence, la méthode de modélisation multi-agents semble la plus appropriée au thème de la recherche de cette thèse.

Depuis la dernière crise financière, les modèles standards – utilisés par les économistes du courant dominant – sont au centre de critique. Un des cibles de reproche principales est l'hypothèse de l'agent représentatif qui est largement appliquée dans ces modèles. Cette hypothèse suppose que tous les agents dans l'économie sont identiques à propos de leur préférence et de leur caractéris-

tique. Les critiques sont aussi concentrées sur une autre supposition régulièrement utilisée dans les modèles standards, à savoir l'hypothèse de l'anticipation rationnelle. Cette hypothèse présume que les agents ont la connaissance de tous les modèles dans l'économie et intègrent parfaitement toute information dans leur prise de décision.

D'un autre côté, comparés aux modèles standards, les modèles multi-agents considèrent le processus économique comme une collection d'agents hétérogènes avec interactions entre eux, et les interactions périodiques entre agents amènent à une configuration constamment variée au niveau microéconomique. La méthode de modélisation multi-agents présente plusieurs avantages (voir Gaffard et Napoletano, 2012 pour une revue). Une des caractéristiques principales de ce type de modélisation est l'incorporation de l'hétérogénéité des agents. Cet avantage décisif donne l'opportunité d'étudier l'évolution des agents avec attribut continuellement varié qui est indispensable pour le sujet de la recherche.

De plus, au contraire des modèles classiques, les agents dans les modèles multi-agents n'incluent pas les équations de l'ensemble du système économique et la totalité de l'information dans leur processus de prise de décision. En conséquence, au lieu de calculer la maximisation inter-temporelle dans les modèles standards, les décisions de ces agents sont faites en suivant des règles prédéfinies (voir par exemple Fagiolo et Roventini, 2012). Cette caractéristique des modèles multi-agents permet d'analyser les réactions des agents aux changements de différents facteurs selon des scénarios respectifs.

Un autre avantage des modèles multi-agents est qu'il n'est pas nécessaire que les interactions entre les agents soient déterminées au sein d'un équilibre, qui implique que tous les marchés dans le système économique construit soient à l'équilibre. Cet attribut correspond au fait que l'équilibre ne peut être permanent dans tous les marchés du système économique. La différence entre les modèles multi-agents et les modèles standards fournit la possibilité d'étudier des questions distinctes en présence de déséquilibre économique.

Par ailleurs, les modèles multi-agents aussi proposent des avantages en termes de flexibilité de modélisation. Par exemple, ces modèles permettent les interactions entre les agents d'être

réalisées via des variables diverses, par opposition aux modèles classiques dans lesquels le prix est souvent le seul élément possible qui permet d'obtenir l'équilibre. Egalement, étant différents des modèles standards, les interactions dans les modèles multi-agents peuvent être achevées au travers d'un réseau décentralisé, qui donne l'opportunité d'analyser la dynamique de système économique complexe (voir par exemple Delli Gatti et al., 2009).

Plan de thèse

La thèse est composée de trois chapitres. Tous les trois sont basés sur le même socle théorique et déclinent des variantes d'une même modélisation qui fait appel à la simulation numérique. Dans le modèle de base, les firmes produisent un produit homogène via une technologie de type Leontief et au moyen de capital et de travail. La compétition entre les firmes est réalisée à travers le prix. L'hétérogénéité des firmes est essentiellement représentée par leur niveau de productivité, et en conséquence leurs décisions de production et leurs conditions de financement. Les firmes financièrement fragiles doivent subir un coût de capital plus élevé et probablement un rationnement de crédit. Des chocs exogènes prédéfinis, comme changement de la demande globale intervient durant les simulations. Dans chaque période, les nouvelles firmes étant attirées par des perspectives de profit entrent dans le marché. En même temps, les firmes ayant échoué dans la compétition quittent l'industrie.

Basés sur le fondement de modélisation et de simulation partagé, les trois chapitres étudient différents sujets en analysant les mêmes facteurs explicatifs, qui consistent en la présence des contraintes financières et les fluctuations des conditions macroéconomiques.

Premier chapitre

Afin de répondre à la première question de recherche, ce premier chapitre est considéré comme central pour la thèse. Il fournit la base de modélisation et de simulation, qui seront la référence pour toutes les trois études menées. Les résultats de simulations montrent qu'en présence des

fluctuations macroéconomiques et des contraintes financières, la pression en provenance de la compétition de marché pourrait conduire à un processus de sélection de marché inefficient, dans lequel les firmes installées dans le marché de longue date, avec une situation financière robuste mais un niveau de productivité relativement faible, peuvent survivre. En revanche, les jeunes ou petites firmes, avec une condition financière fragile sont obligées de quitter le marché, même si elles sont plus productive.

La raison d'un tel dysfonctionnement du mécanisme de sélection de marché pourrait être tout d'abord le renforcement mutuel entre les contraintes financières et les conditions macroéconomiques détériorées. D'un côté, la présence des contraintes financières provoque des conditions de financement différentiées parmi les firmes. La contraction des facteurs macroéconomiques affaiblit la situation financière des firmes et aggrave la disparité entre les firmes concernant leur capacité de financement. Par conséquent, les fluctuations macroéconomiques exacerbent l'impact des restrictions financières sur les firmes.

D'un autre côté, quand la solidité financière des firmes est largement réduite pendant la récession, l'existence des contraintes financières amplifie l'augmentation du coût de capital des firmes en situation de détresse, voire les impose un rationnement de crédit. Cette hausse du coût de capital aggrave la perte de ces firmes et diminue leur chance de survie. Ainsi, les contraintes financières agissent comme un accélérateur en empirant les effets des conditions macroéconomiques dégradées sur les firmes et en précipitant la sortie du marché des firmes les plus vulnérables.

Les effets mutuellement intensifiés de ces deux déterminants combinés ensemble pourraient aboutir à des conséquences plus néfastes aux firmes, en particulier celles traditionnellement souffrent plus les contraintes financières, c'est-à-dire les jeunes et petites firmes. Ainsi, la combinaison des deux déterminants, l'un est au niveau macroéconomique, l'autre vient de sphère microéconomique, fortifie leurs répercussions respectives sur l'économie en impactant sur la structure de la compétition de marché. L'apparition de la détérioration macroéconomique aggrave l'influence des imperfections financières sur les firmes, qui à son tour empire la déchéance de l'économie à travers son impact sur l'investissement et la survie des firmes, et par la suite, l'emploi et la consommation.

Par ailleurs, la défaillance du processus de sélection de marché pourrait également être expliquée par une autre raison plus profonde qui consiste en la divergence entre les compétitions du marché de produit et celles du marché de crédit. Sous la condition idéale d'un marché parfaitement efficient, la compétition dans le marché de produit est uniquement basée sur la productivité des firmes, et dans le marché de crédit leur solidité financière. Pendant la période où les conditions économiques sont normales, les deux critères sont parfaitement corrélés, qui veut dire que les firmes avec une productivité supérieure sont aussi financièrement plus performantes et plus solides.

En revanche, pour une firme un délai peut exister entre l'amélioration immédiate de profitabilité due à sa productivité élevée et le renforcement de sa solidité financière, étant donné le fait que pour une firme de taille relativement petite, un profit positif à court terme ne peut radicalement modifier son état de solvabilité. Au contraire, il est nécessaire d'avoir des profits positifs pendant un certain nombre de périodes successives afin de renforcer les capitaux propres de la firme, et en conséquence sa solvabilité. Cette situation discordante pourrait arriver surtout quand les contraintes financières strictes et les conditions économiques détériorées ont lieu en même temps. Pourtant, en réalité les deux facteurs arrivent souvent conjointement.

Conditionnées par les circonstances spécifiques, certaines firmes avec une situation financière affaiblie et une taille limitée voient leurs conditions de financement restent sévères, en dépit de leur profitabilité améliorée. Par conséquent, certaines parmi eux pourraient tomber en faillite avant que la pression des contraintes financières soit significativement atténuée, malgré leur niveau de productivité élevé. Pour cette raison, la présence des contraintes financières et les conditions macroéconomiques rigoureuses pourraient élargir le décalage entre les compétitions dans les deux marchés, qui finalement provoque l'apparition d'un mécanisme de sélection de marché inefficient.

Le travail de ce chapitre contribue essentiellement à la littérature existante concernant la dynamique des firmes. Le dysfonctionnement du mécanisme de sélection de marché en présence des contraintes financières et des chocs de la demande globale démontre une plausible défaillance du marché, sous l'impact des imperfections financières et de la détérioration de l'environnement macroéconomique. Par ailleurs, les résultats de cette étude contestent les arguments des effets dits

« cleansing ». Au contraire de ce qui est affirmé, sous des conditions spécifiques le fonctionnement de la sélection de marché pourrait être entravée pendant la récession économique.

Deuxième chapitre

Le deuxième chapitre répond à la deuxième question de recherche. En utilisant la même base de modélisation, la dynamique de productivité des firmes et leurs dépenses en R&D dans les modèles de ce chapitre sont considérés comme des éléments endogènes. Les résultats de simulations montrent que sous l'influence des contraintes financières et des conditions macroéconomiques sévères, il pourrait exister une distorsion de la structure de marché en termes des modes d'investissement en R&D, où les firmes ayant la volonté d'engager des investissements en R&D proportionnellement substantiels, en particulier celles qui investissent dans des projets de recherche exploratoires, sont davantage éliminées par la compétition du marché. Cependant, les autres firmes ayant la préférence d'investir plutôt dans le capital physique survivent pendant la récession grâce à leur situation financière plus solide.

La distorsion de la structure de marché est causée conjointement par l'incertitude du rendement de l'investissement en R&D et la combinaison des contraintes financières et des conditions macroéconomiques détériorées.

Dans les modèles de ce chapitre, chaque firme doit prendre leur décision d'investissement périodique entre le capital physique et les activités de R&D, en même temps, l'investissement en R&D peut être financé seulement par des fonds internes. En plus, au sein de l'investissement en R&D, chaque firme prend la décision entre des projets de recherche sûrs et risqués. En conséquence, selon leur proportion d'investissement dans le capital physique, les firmes sont caractérisées comme pro-capital ou pro-R&D. basé sur leur pourcentage d'investissement dans des projets de recherche sûrs, les firmes sont classées en termes des profils de R&D comme pro-sécurité ou pro-risque.

Comme ce qui est étudié dans les recherches précédentes, une des particularités principales de l'investissement en R&D est l'incertitude sur son futur rendement. Dans le contexte de cette étude, le résultat d'un investissement en R&D réussi se traduit en une amélioration de productivité de la

firme en question. En même temps, l'incertitude est une fonction décroissante de la quantité de fonds investis dans les activités de R&D.

L'existence de l'incertitude sur le rendement et l'arbitrage en termes d'investissement entre le capital physique et les activités de R&D conduisent à une relation qui indique que plus une firme investit en R&D, moins elle supportera l'incertitude sur l'amélioration future de sa productivité, en parallèle, elle devient aussi plus dépendante des sources de financement externes. Par ailleurs, parce que les projets de R&D risqués ont une incertitude sur le rendement plus élevée que celle des projets plus sûrs mais apportent potentiellement un meilleur gain de productivité, les firmes qui tentent d'engager plus d'investissement dans le domaine risqué souffrent plus d'incertitude en termes du rendement et de situation financière difficile.

Pendant les périodes normales, par augmenter les profits futurs, le gain potentiel de productivité des firmes avec haute intensité d'innovation compense leur désavantage par rapport au coût de capital élevé dû à une situation financière moins solide. Pourtant, sous les conditions macroéconomiques rigoureuses et persistantes, la situation financière de l'ensemble des firmes est affaiblie. La présence des restrictions financières empire les conditions de financement des firmes en détresse en haussant les taux d'intérêt et en imposant le rationnement de crédit. Les firmes avec un mode d'investissement plutôt pro-R&D, surtout celles qui se concentrent sur des projets risqués, représentent la majorité des firmes sortantes, sous la pression des contraintes financières à cause de leur faible niveau de capitaux propres, suite à leur investissement en R&D intensif.

La notion de l'incertitude sur le rendement futur aussi implique le fait qu'une incertitude plus élevée entraîne une probabilité plus faible de réalisation de gain de productivité à court terme.

Etant donné le rapport croissant entre les activités de R&D et la progression de productivité, le découragement de l'investissement en R&D provoqué par la distorsion de la structure de marché pourrait également affecter la dynamique de productivité des firmes à long terme.

La contribution de cette étude consiste en une nouvelle vision sur la probabilité de survie des firmes d'un point de vue de l'investissement en R&D, qui indique une plausible distorsion du processus de sélection de marché, dans lequel les firmes avec haute intensité d'innovation sont large-

ment désavantagées sous l'influence des contraintes financières et des conditions macroéconomiques sévères.

Troisième chapitre

Les travaux du troisième chapitre essaient de répondre à la troisième question de recherche. Il a pour objective d'analyser le mécanisme de transmission de la politique budgétaire à la dynamique des firmes effectué à travers le canal d'investissement et de la dynamique de productivité des firmes. Les résultats de simulations apportent la lumière sur l'existence d'un effet significatif d'une augmentation de la demande globale sur l'investissement des firmes. En revanche, cet effet est altéré par une distorsion de la compétition de marché à cause de la présence des contraintes financières et d'un contexte économique difficile.

Une relance économique est représentée au niveau des firmes par une hausse brusque de la demande. Cette augmentation rapide de demande stimule les firmes à agrandir leur production en utilisant la quantité nécessaire des facteurs productifs, qui implique un investissement substantiel en capital. L'augmentation de capital améliore la santé financière d'une firme, qui en suite permet à elle d'investir plus et de réduire son coût de capital.

Cependant, les firmes ne sont pas égales dans cette vague d'investissement. Seulement celles avec meilleure solidité financière et donc moins restreintes – sans le risque de rationnement de crédit et bénéficier des taux d'intérêts relativement plus bas – peuvent entièrement profiter de la politique de relance. Les autres firmes ne peuvent qu'investir avec limitation à cause de leurs taux d'endettement élevés. La disparité en termes de conditions de financement pourrait persister dû au fait que les firmes qui souffrent moins de pression des contraintes financières peuvent renforcer leur position dans le marché en améliorant leur structure financière et agrandir leur taille. En revanche, ce processus est plus difficile à achever pour les firmes financièrement limitées.

En plus, cette inégalité est intensifiée quand le contexte économique d'une telle relance économique est sévère. Puisque la situation financière des firmes est généralement affaiblie, la disparité des conditions de financement entre les firmes est aggravée. En conséquence, devant

l'arrivée d'une hausse de la demande globale, le déséquilibre d'investissement et d'expansion entre les firmes est plus amplifié.

Pour conclure, il est clair que le cycle économique inflige une influence significative sur le résultat d'une politique de stimulation macroéconomique. Au contraire de ce que l'on peut observer pendant les périodes d'expansion, une mesure de relance pendant la récession a des effets plus différentiés sur la dynamique des firmes, à cause de leur situation financière affectée, en particulier pour les jeunes et petites firmes. La présence des contraintes financières a deux effets en parallèle sur le résultat d'une relance économique. D'une part, l'existence de restrictions financières intensifie la réaction de l'investissement des firmes face à une augmentation de la demande globale. D'autre part, il aggrave la disparité entre les firmes concernant la possibilité de croissance et de survie.

Au sujet de contribution, les résultats de cette étude soulignent les effets mitigés d'une relance économique sur les firmes, plus précisément, une inégalité intensifiée entre les firmes en termes d'opportunité de bénéficier d'une augmentation de la demande globale dans un contexte de récession.

Modélisation de référence

On construit un modèle multi-agents dans lequel les firmes sont hétérogènes selon leur productivité et leur situation financière. Dans la modélisation, l'industrie évolue en temps discret $t = 1, 2, ...,$ les firmes dans l'industrie sont dénommées par $i = 1, 2, ...$ Au moyen de capital K_{it} et travail L_{it}, les firmes produisent et vendent a produit homogène avec différents prix p_{it} dans un marché compétitif. Dans chaque période les firmes prennent leur décision en termes de production et d'investissement, en prenant en compte les contraintes financières et les fluctuations des facteurs macroéconomiques.

Production

Les firmes produisent avec rendements d'échelle constants à travers une technologie de type Leontief. La fonction de production est la suivante :

$$Y_{it} = min\{K_{it}, \theta_{it} L_{it}\}$$

où Y_{it} est la production, θ_{it} est la productivité du travail.

Le coût total de chaque firme TC_{it} est calculé par

$$TC_{it} = r_{it}(A_{it} + B_{it}) + \delta K_{it} + w_t L_{it} + F$$

dans l'équation r_{it} représente les taux d'intérêt, A_{it} et B_{it} signifient respectivement les capitaux propres et la dette. Dans l'intérêt de simplicité, on considère les sources du capital en provenance des actionnaires et des prêts bancaires ont le même niveau de coût, en supposant que les firmes distribuent les dividendes aux actionnaires comme rémunération au même niveau que les taux d'intérêt à chaque période. δ désigne le taux de dépréciation du capital productif. w_t est le salaire. Le coût du travail est supposé comme exogène. F indique les coûts fixes.

Supposons qu'il n'existe pas de restriction en quantité du travail, on peut ainsi écrire :

$$K_{it}^* = Y_{it}^*, L_{it}^* = \frac{Y_{it}^*}{\theta_{it}}$$

où Y_{it}^* représente la production réelle, K_{it}^* est la quantité nécessaire du capital utilisé dans la production. En excluant la possibilité de désinvestissement, en cas de contraction économique, le taux d'utilisation de la capacité productive peut être inférieur à 100%. Autrement dit, $K_{it}^* \leq K_{it}$. L_{it}^* correspond à la quantité réelle de l'autre facteur productif.

Donc le coût unitaire d'une firme doit être :

$$UC_{it} = \frac{TC_{it}}{Y_{it}}$$

On emploie une structure de bilan simplifiée dans laquelle les firmes financent leur activités productives avec leurs capitaux propres et dette, et écartent la possibilité d'émission de nouvelles actions. En éliminant l'existence de stock, les actifs courants qui consistent en liquidité $\pi_{it} + \delta K_{it}$ constituent la capacité d'autofinancement d'une firme. On également simplifie le bilan en supposant que les firmes toujours préfèrent rembourser leur emprunt quand leur capacité d'autofinancement est disponible. En d'autres termes, les actifs courants reduisent la dette. Ainsi, une dette négative indique une réserve cumulative de capacité d'autofinancement positive.

$$B_{it} = B_{it-1} - (\pi_{it-1} + \delta K_{it-1})$$

Par conséquent, $K_{it} = A_{it} + B_{it}$. Basée sur cette supposition, le coût marginal MC_{it} peut être obtenu comme la suivante :

$$MC_{it} = r_{it} + \delta + \frac{w_t}{\theta_{it}}$$

Demande

On suppose que la valeur de la demande globale évolue avec un taux de croissance exogène g_t.

$$D_t = (1 + g_t)D_{t-1}$$

Donc la demande du marché en quantité à chaque firme est :

$$d_{it} = \frac{s_{it}D_t}{p_{it}}$$

où p_{it} indique le prix et s_{it} est la part de marché de chaque firme. La part de marché est calculée par une comparaison entre le prix d'une firme et le prix moyen du marché dans la période précédente. λ peut être considéré comme l'élasticité de la demande au prix, il mesure la sensibilité de la demande d'un produit en quantité au changement de son prix par rapport à la moyenne du marché, et $\lambda > 0$. Quand $\lambda < 1$ la demande est moins élastique qui signifie que le changement de

la demande est faible comparé au changement du prix. Quand $\lambda > 1$ la demande est plus réactive au mouvement du prix. Avec l'expression

$$s_{it} = (\frac{s_{it-1}}{p_{it-1}})^{\lambda} / \sum_{i} (\frac{s_{it-1}}{p_{it-1}})^{\lambda}$$

On introduit aussi un indice du prix du marché $\overline{P}_t$ calculé comme la moyenne pondérée des prix :

$$\overline{P}_t = \frac{\sum_i p_{it} Q_{it}}{\sum_i Q_{it}}$$

où Q_{it} est la quantité vendue, $Q_{it} = min\{Y_{it}, d_{it}\}$.

Le profit de chaque firme est en conséquence la différence entre le chiffre d'affaire et le coût total :

$$\pi_{it} = p_{it} Q_{it} - TC_{it}$$

Décision de production

Supposons que les firmes observent la demande du marché au début de chaque période. En connaissance du volume de la demande, une firme peut déterminer sa quantité de production désirée avec $\hat{Y}_{it} = d_{it}$. Considérons les coûts des facteurs de production r_{it} and w_t, la demande d_{it} et le niveau de productivité θ_{it} comme donnés.

Dans les travaux de recherche précédents, la détermination du prix emploie des mécanismes variés. Le prix peut être fixé à une valeur constante (voir par exemple Clementi et Palazzo, 2010), ou aux alentours du prix du marché (voir par exemple Napoletano et al., 2005), ou dans un interval (voir par exemple Assenza et al., 2007) ou encore avec un taux de marge fixe (voir par exemple Dosi et al., 2010). Dans cette modélisation, sachant le niveau du coût marginal, les firmes fixent leur prix en ajoutant une marge à leur coût marginal.

$$p_{it}^{*} = (1 + \mu_{it}) MC_{it}$$

où la marge endogène μ_{it} est supposée d'être la fonction de la part de marché de la firme en question dans la période antérieure :

$$\mu_{it} = \mu_0 + \alpha s_{it-1}^{\beta}$$

Dans cette équation, la constante μ_0 représente le niveau minimum de la marge dont une firme a besoin, les deux paramètres α et β définissent la relation entre la part de marché d'une firme dans la période passée et son niveau de marge actuel. Ce mécanisme est dans le même esprit que Dosi et al. (2010) mais appliqué différemment. Dans leur modélisation la marge d'une firme dans la période t est une fonction de sa marge en $t-1$ et de sa part de marché dans les deux périodes précédentes $t-1$ et $t-2$. Le mécanisme utilisé ici correspond aussi indirectement à l'argument de Campbell et Hopenhayn (2005), que la hausse du nombre de concurrents a un impact négatif sur la marge des firmes. Plus de concurrents signifie une part de marché plus faible, qui devrait faire baisser le niveau de marge.

A travers ces équations on peut ainsi déterminer le volume de production et le prix désirés :

$$p_{it}^{*} = (1 + \mu_{it})(r_{it} + \delta + w_t/\theta_{it})$$
$$\hat{Y_{it}} = \frac{s_{it} D_t}{(1 + \mu_{it})(r_{it} + \delta + w_t/\theta_{it})}$$

Au début de chaque période, quand une firme a fixé son prix p_{it}^{*} et son objectif de production $\hat{Y_{it}}$, elle définit aussi sa quantité de capital $\hat{K_{it}}$ et travail $\hat{L_{it}}$ désirée, selon la production et les coûts des facteurs productifs. Une firme peut ajuster sa quantité de travail au taux de salaire du marché sans obstacle. Cependant, si son capital cumulé n'est pas suffisant par rapport à son objectif, elle doit chercher des sources de financement via les intermédiaires externes, d'où vient le problème des contraintes financières que l'on introduira ci-dessous.

Capitaux propres, dette, actifs et investissement

En supposant que les firmes ne peuvent augmenter leur capital par le biais de l'émission de nouvelles actions, l'évolution des capitaux propres d'une firme A_{it} est strictement reliée à son profit de la période passée :

$$A_{it} = A_{it-1} + \pi_{it-1}$$

D'une façon traditionnelle, la dynamique du capital productif est définie par le rythme de dépréciation et la valeur d'investissement I_{it} :

$$K_{it} = (1-\delta)K_{it-1} + I_{it-1}$$

En cas d'accroissement d'activités, le capital désiré est en hausse, un investissement dans l'actif productif est nécessaire.

$$\hat{I}_{it} = \begin{cases} \hat{K}_{it} - (1-\delta)K_{it-1} & \text{if } \hat{K}_{it} > (1-\delta)K_{it-1} \\ 0 & \text{otherwise} \end{cases}$$

En considérant le cas sans l'émission de nouvelles actions, le capital productif a deux sources de financement : autofinancement et prêt par les intermédiaires financiers externes. Selon les théories de la hiérarchie des préférences, les firmes toujours préfèrent les fonds internes à l'emprunt bancaire comme sources de financement. Dans ce contexte, on suppose que les firmes toujours considèrent dans un premier temps à utiliser leur capacité d'autofinancement. Correspondant aux actifs courants positifs cumulés, l'autofinancement peut ainsi être décrit comme la suivante :

$$\begin{cases} |B_{it-1}| & \text{if } B_{it-1} < 0 \\ 0 & \text{otherwise} \end{cases}$$

En cas de capacité d'autofinancement insuffisante, les firmes sont obligées de demander à l'emprunt bancaire BL_{it}.

Productivité

On applique ici un mécanisme simple de choc pour faire évoluer la productivité des firmes. Basé sur son niveau dans la période précédente, chaque firme reçoit un choc périodique de productivité, qui suit la distribution normale. Dans l'intérêt d'effectuer les simulation avec stabilité, il est important de maintenir un état stationnaire relatif de la productivité agrégée, afin d'analyser l'impact des contraintes financières et des fluctuations des conditions macroéconomiques sur la dynamique des firmes. Pour atteindre cet objectif, on introduit une constante ϑ qui attache la dynamique de productivité conjointement à sa valeur initiale et périodique.

$$\theta_{it} = \vartheta\theta_{it-1} + (1-\vartheta)\overline{\theta}_{i0} + \epsilon_{it}$$

où $\epsilon_{it} \sim N(0, \sigma_\epsilon^2)$, $0 \leq \vartheta \leq 1$.

Contraintes financières

La dette des firmes B_{it} suit une dynamique de renouvellement périodique. A la fin de chaque période la dette est remboursée et au début de la période suivante une nouvelle dette B_{it+1} est engagée.

Comme ce qui est expliqué précédemment, les contraintes financières sont un des déterminants principaux de la dynamique des firmes. Dans la modélisation, les contraintes se traduisent en taux d'intérêt variables qui dépendent de la robustesse financière d'une firme, également en rationnement de crédit que les firmes avec un taux d'endettement élevé sont obligées de subir.

Inspiré par Napoletano et al. (2005), on définit les taux d'intérêt comme déterminés par le taux sans risque r_f, le taux d'endettement moyen des firmes $\overline{b_t}$ et l'écart entre le taux d'endettement d'une firme b_{it} et le taux d'endettement le plus bas dans l'industrie b_t^{min}, où $b_{it} = \frac{B_{it}}{K_{it}}$.

$$r_{it} = r_f[1 + \rho f(\overline{b}_{t-1}) + \varrho(1-\rho)g(b_{it-1} - b_{t-1}^{min})]$$

Dans cette équation, ρ délimite la proportion des deux déterminants des taux d'intérêt et

$0 < \rho < 1$. ϱ est un coefficient de l'écart des taux, $\varrho > 0$. $f'(.) < 0$ et $g'(.) > 0$. Ici trois éléments déterminent le taux d'intérêt d'une firme. Quand son taux d'endettement est élevé comparé à la firme avec meilleure performance financière, ou la situation financière de l'ensemble des firmes est affaiblie, ou encore l'écart des taux est élargi, le taux d'intérêt d'une firme augmente en conséquence.

Dans cette modélisation les taux d'intérêt jouent un rôle central dans l'influence des contraintes financières. Comme Delli Gatti et al. (2009), on peut dire que l'échelle de production d'une firme est financièrement restreinte : elle est limitée par sa situation financière via le mécanisme de détermination des taux d'intérêt.

L'emprunt bancaire désiré par une firme dépend de la valeur d'investissement requise et sa capacité d'autofinancement. On peut détailler cette relation dans l'expression suivante :

$$\hat{BL}_{it} = \begin{cases} \hat{I}_{it} & \text{if } B_{it-1} \geq 0 \\ \hat{I}_{it} - |B_{it-1}| & \text{if } B_{it-1} < 0 \ \ and \ \ |B_{it-1}| < \hat{I}_{it} \\ 0 & \text{if } B_{it-1} < 0 \ \ and \ \ |B_{it-1}| \geq \hat{I}_{it} \end{cases}$$

Le rationnement de crédit constitue une autre contrainte financière aux firmes. Si une firme peut dépasser sa limite de solvabilité avec la valeur de son objectif d'emprunt BL^*_{it}, le crédit sera seulement accordé en partie. Cette mesure signifie que les intermédiaires financiers essaient de limiter les dommages potentiels liés au risque de défaillance en restreignant le taux d'endettement de leurs clients. En conséquence, sachant la combinaison des facteurs productifs permettant d'obtenir le coût de production périodique le plus bas, la firme en question doit réduire sa production ainsi la quantité de ses autres facteurs productifs.

On introduit un seuil de taux d'endettement maximum b^{thr}_t comme une limite selon laquelle les banques peuvent financer une firme. Le volume d'emprunt sera restreint si le taux d'endettement dépasse ce seuil. Donc l'emprunt bancaire réel est déterminé de manière suivante :

$$BL_{it} = \begin{cases} \hat{BL}_{it} & \text{if } (\hat{BL}_{it} + B_{it-1})/\hat{K}_{it} < b_t^{thr} \\ b_t^{thr}\hat{K}_{it} - B_{it-1} & \text{otherwise} \end{cases}$$

Entrée et sortie

Plusieurs courants existent dans la littérature de dynamique des firmes à propos de leur processus d'entrée dans le marché. Par exemple, Winter et al. (2003) utilisent un mécanisme stochastique pour déterminer les nouveaux entrants. Mais d'une manière plus traditionnelle, on applique un processus endogène. Proposé par Jaimovich (2007) et Hopenhayn (1992), à travers un calcul d'optimisation, le nombre de nouveaux entrants dépend du niveau de marge de l'industrie, des coûts d'entrée et de leur choc de productivité individuel. Les études récentes essaient d'améliorer ce mode de détermination. Clementi et Palazzo (2010) attribuent les nouveaux entrants des caractéristiques hétérogènes. Delli Gatti et al. (2003) construisent un modèle dans lequel le nombre d'entrants est une fonction croissante du nombre des firmes en place, et la valeur des capitaux propres des nouveaux entrants suit la distribution normale.

Basé sur la littérature et les faits stylisés concernant le profil des nouveaux entrants, ici on modélise le nombre d'entrants N_t^e est croissant de la moyenne pondérée du taux de profit de l'industrie Π_t et décroissant des coûts d'entrée c_e.

$$N_t^e = round[\chi_t]$$

avec $\chi_t \sim N(\chi_t, \sigma_{\chi_t}^2)$, et la fonction d'arrondissement $f(x) = [x]$ garantit que le nombre soit un intègre. La valeur de χ_t est déterminée directement par la moyenne pondérée du taux de rendement de capital et les coûts d'entrée :

$$\chi_t = \frac{\Pi_{t-1}}{c_e}\Omega$$

Dans cette équation, $\Pi_t = \frac{\sum_i \pi_{it} Q_{it}/K_{it}}{\sum_i Q_{it}}$, Ω est un paramètre qui permet de calibrer le taux d'entrée dans les simulations pour qu'il soit proche des faits stylisés.

Deux caractéristiques importantes des nouveaux entrants doivent être déterminées quand ils entrent dans le marché : leur productivité et leur taille. Selon les faits stylisés, on suppose que la productivité d'un entrant θ_{it}^e est tirée d'une distribution log-normale, avec la moyenne $\mu_{\theta_{it}^e}$ liée à la productivité moyenne des firmes en place Θ_t via le paramètre τ_θ et $\tau_\theta \geq 1$.

$$\theta_{it}^e \sim logN(\tau_\theta \Theta_{t-1}, \sigma^2_{\Theta_{t-1}})$$

De façon similaire, comme un élément représentatif de la taille, le niveau de production d'un nouvel entrant Y_{it}^e suit une distribution log-normale, il est indépendant de la productivité initiale.

$$Y_{it}^e \sim logN(\tau_Y \overline{Y}_{t-1}, \sigma^2_{\overline{Y}_{t-1}})$$

avec $\tau_Y < 1$, qui signifie que la plupart des nouveaux entrants sont plus petits que la taille moyenne des firmes en place.

Le prix de chaque nouvel entrant p_{it}^e suit une règle de marge nulle.

$$p_{it}^e = MC_{it}^e$$

La modélisation implique aussi la détermination de part de marché de chaque entrant au moment de leur première apparition dans le marché, pareillement pour les firmes en place. La réallocation des parts de marché inclut deux dynamiques : une nouvelle firme entre dans le marché, produit et vend son produit. En même temps, les firmes en place observent que la demande du marché vers leur produits baisse, donc elles produisent et vendent moins.

En conséquence, la part de marché d'un nouvel entrant dépend de son niveau de production initial. Utilisons s_{it}^e comme sa part de marché initiale, on obtient :

$$s_{it}^e = \frac{p_{it}^e Y_{it}^e}{D_t}$$

Afin de simplifier la modélisation, supposons que la réduction de la demande du marché en-

gendrée par l'entrée des nouvelles firmes est distribuée de manière homogène à toutes les firmes en place. Ainsi la part de marché de chacune des firmes en place après l'arrivée des nouveaux entrants sera :

$$s_{it}^{*} = s_{it} - \frac{\sum_i s_{it}^{e}}{N_t^i}$$

où N_t^i représente le nombre des firmes en place.

Deux critères sont établis pour déterminer la sortie des firmes. Le premier seuil est la part de marché minimum s_{min} : les firmes avec une part de marché inférieur à cette limite seront considérées comme trop petite pour subsister. Le deuxième critère s'appuie sur la valeur des capitaux propres. Les firmes avec une valeur de capitaux propres négative deviennent insolvables, elle doivent donc quitter le marché.

Simulations de référence

En suivant les travaux de recherche précédents et les faits stylisés, on détermine la valeur des paramètres structurels et des conditions initiales en tant que cadre de simulations référentielles. Plus précisément, les simulations contiennent 300 firmes initialement et déroulent pour 1000 périodes. Les trois tableaux suivants donne respectivement le paramétrage des éléments nécessaires pour les simulation, y compris les paramètres structurels, les conditions de simulation initiales et les paramètres des nouveaux entrants.

Le paramétrage est basé sur les statistiques des études empiriques. Par exemple, fondé sur les études de Meeks (2012), Guntay et Hackbarth (2010) et Loncarski et Szilagyi (2012), l'intervalle principal des taux d'intérêt est délimité entre 4% et 8%. Même si la distribution des taux d'endettement est relativement dispersée en fonction des pays et des secteurs, selon les études de Egger et al. (2010) et de Jong et al. (2011), le taux d'endettement de nouveaux entrants est fixé à 50%.

On effectue les simulations de référence avec les conditions agrégées stables afin de confirmer

Description	Symbole	Valeur
Taux de dépréciation de capital	δ	0.025
Taux d'intérêt sans risque	r_f	0.01
Coefficient de la prime de risque	ρ	0.30
Paramètre de l'écart des taux d'intérêt	ϱ	2
Limite d'emprunt	b^{thr}	100%
Coût du travail	w	0.5
Constante de marge	μ_0	0.04
Paramètre de marge	α	20
Paramètre de marge	β	1
Coûts fixes	F	8
Paramètre de part de marché	λ	1
Limite de part de marché en tant que seuil de sortie	s_{min}	0.02%
Paramètre de choc de productivité	ϑ	0.8

Paramétrage structurel

Description	Symbole	Valeur
Nombre de firmes	N	300
Nombre de périodes	T	1000
Demande globale	D_t	30000
Part de marché	s_{i1}	0.33%
Taux d'endettement	b_{i1}	50%
Productivité	θ_{i1}	4.0

Conditions initiales

Description	Symbole	Valeur
Coût d'entrée	c_e	1
Paramètre du nombre de nouveaux entrants	Ω	1000
Variance du nombre de nouveaux entrants	$\sigma^2_{\chi t}$	0.2
Paramètre de productivité	τ_θ	1
Variance de productivité	$\sigma^2_{\Theta_{t-1}}$	0.05
Paramètre de production	τ_Y	0.6
Variance de production	$\sigma^2_{\overline{Y}_{t-1}}$	0.07

Paramétrage de nouveaux entrants

la robustesse de la modélisation et de la programmation. Les simulations de référence permettent également d'analyser les caractéristiques principales de la dynamique des firmes comme les résultats de la modélisation. On considère dans les simulations qu'une période correspond à un trimestre, ainsi, pour les études statistiques des résultats de simulations, la somme de quatre périodes est équivalente à un an.

Dans l'intérêt de paramétrer les modèles afin d'obtenir des résultats de simulations proches des faits stylisés, on réalise une série de statistiques comme cibles du paramétrage, tirés dans la littérature en particulier concernant la dynamique des firmes (voir Bellone et al., 2008, Lee et Mukoyama, 2012, Bartelsman et al., 2005, Bartelsman et al., 2009 et Cooper et Haltiwanger, 2006). Le tableau suivant présente la comparaison entre les cibles du paramétrage et les résultats de simulations pour les éléments principaux en termes de dynamique des firmes. Les résultats des taux d'entrée, de sortie et de renouvellement, ainsi la taille relative des entrants et des sortants par rapport aux firmes en place sont conformes aux faits stylisés.

Description	Données empiriques Annuel	Résultats de simulations			
		Par période		Annualisé	
		Moyenne	Médiane	Moyenne	Médiane
Taux d'entrée	6% - 10%	1.78%	1.73%	7.12%	6.91%
Taux de sortie	8% - 15%	1.71%	1.69%	6.83%	6.77%
Taux de renouvellement	15% - 20%	3.48%	3.43%	13.94%	13.68%
Taille relative des entrants	60%	56.70%	56.64%		
Taille relative des sortants	49%	30.63%	30.12%		

Simulations de référence - cibles du paramétrage

Les graphiques suivants présentent un certain nombre de caractéristiques de base obtenues des résultats de simulations. L'évolution du nombre de firmes en place et du taux de renouvellement illustrent un état stationnaire après 200 périodes de simulation, ainsi que l'indice de Herfindahl, le taux de marge moyenne et le taux du rendement de capital moyen. Tout cela démontre un environnement de compétition de marché stable.

Parmi les autres indicateurs de la dynamique agrégée, la productivité agrégée, le prix moyen

et la production agrégée varient dans un intervalle étroit. Correspond à la productivité agrégée en progression régulière, le prix moyen du marché baisse grâce à la réduction du coût de travail. En même temps, la quantité de la production globale augmente graduellement.

On peut remarquer en particulier que la moyenne pondérée de la productivité reste légèrement supérieure à la moyenne arithmétique, bien que toutes les deux fluctuent dans le même rythme. Ceci est dû au poids croissant des firmes relativement plus productives dans le marché. Sous les effets de la sélection du marché, les firmes plus productives gagnent des parts de marché et deviennent plus grandes que le reste. Par conséquent, la moyenne pondérée de productivité reste au-dessus de la moyenne arithmétique.

Egalement être conforme aux faits stylisés, le graphique du nombre de sortants par âge cumulé montre que les jeunes firmes occupent la majorité absolue parmi les firmes sorties du marché. Le graphique de l'âge moyen des sortant conforte cette interprétation.

On introduit trois indicateurs concernant l'évolution de taux de survie des firmes : le taux de survie selon âge, le taux de survie basé sur emploi qui mesure la moyenne de la proportion de quantité de travail totale employée par les firmes survivantes parmi toutes les firmes entrées dans le marché, et le gain net d'emploi des firmes survivantes qui représente la croissance moyenne des survivantes en termes de quantité de travail comparé à leur valeur initiale lors de l'entrée dans le marché.

Les trois graphiques illustrent que la moyenne du taux de survie des firmes décroît avec âge avant de se stabiliser à l'âge de onze ans, pareillement pour la moyenne du taux de survie basé sur emploi. Le gain net d'emploi des firmes survivantes reste légèrement négatif après l'entrée, ensuite augmente rapidement. Egalement, ces résultats sont fidèles aux faits stylisés. Comme ce qui est mentionné dans les études empiriques précédentes, les jeunes firmes ont un taux de défaillance particulièrement élevé. Même si certaines jeunes firmes peuvent persister dans la compétition de marché, elles ont du mal à agrandir. Dans le graphique de simulations, cette affirmation correspond au gain net d'emploi négatif des firmes au début de leur développement après l'entrée. La combinaison du taux de survie bas avec le faible gain net d'emploi des jeunes firmes fait baisser

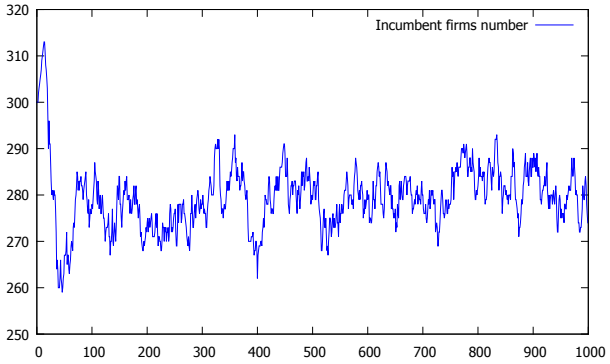
rapidement le taux de survie basé sur emploi après l'entrée des firmes. Concernant les raisons de cette particularité des jeunes firmes en termes de dynamique, comme expliqué par plusieurs études existantes, le fait que le taux de survie et la performance des jeunes firmes sont faibles est dû principalement aux contraintes financières sévères et les effets de taille défavorables que ces firmes subissent.

Conclusion

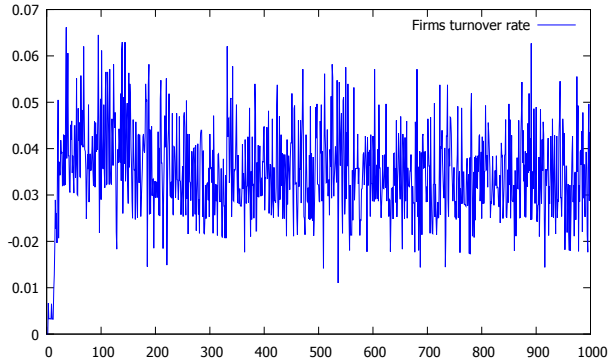
Les études réalisées dans cette thèse nous permettent d'avoir un aperçu profond de la dynamique des firmes en prenant en compte la présence des contraintes financières et le bouleversement des conditions macroéconomiques. Dans un contexte de compétition de marché, l'impact de l'environnement économique détérioré pourrait être plus fort et plus persistant que l'on attendait, à propos du processus de sélection de marché, de la distorsion de la structure de marché en termes du mode d'investissement en R&D et des conséquences d'une relance économique au niveau des firmes.

La défaillance du mécanisme de sélection de marché sous les conditions spécifiques révèle une plausible inefficience de marché, qui pourrait avoir de sérieuses conséquences sur l'économie. Si les firmes avec un niveau de productivité relativement plus élevé pourraient être forcées à quitter le marché, en faveur de celles relativement moins productives, l'allocation des ressources devient inefficiente. En impactant la dynamique de productivité au niveau des firmes, cette inefficience pourrait affaiblir la progression de la productivité agrégée.

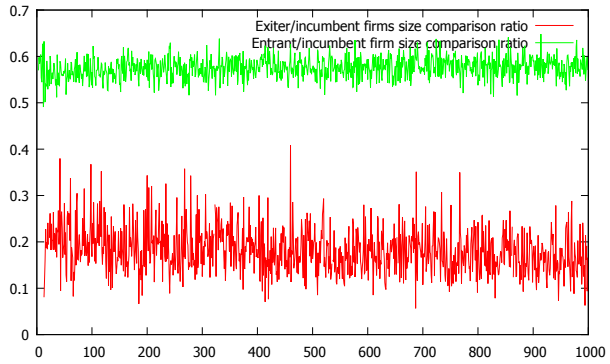
En même temps, le découragement de l'investissement en R&D à cause de l'élimination en forte proportion des firmes avec haute intensité d'innovation pourrait également altérer l'évolution de la productivité agrégée. L'inégalité aggravée entre les firmes face à une relance de l'économie pendant la période de récession pourrait finalement influencer le fonctionnement de la sélection de marché puis la dynamique de productivité des firmes. En conséquence, la combinaison des contraintes financières et des fluctuations des conditions macroéconomiques pourrait affecter la



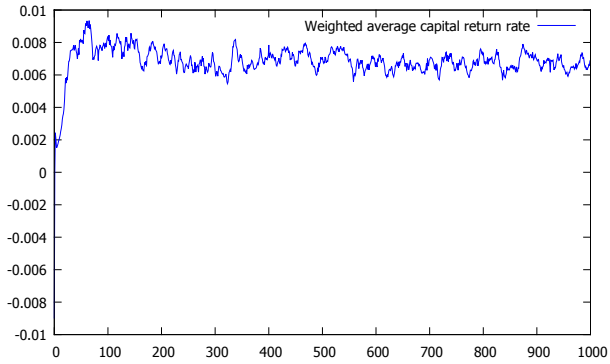
(a) Nombre de firmes en place



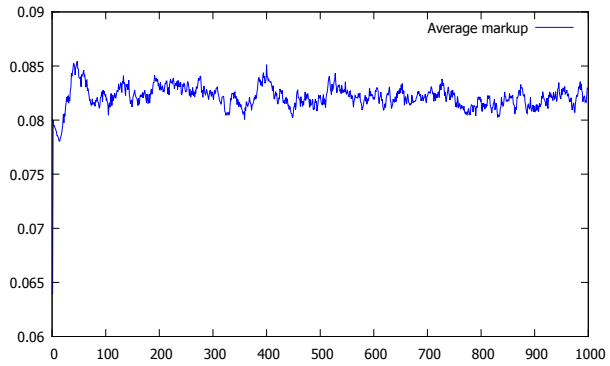
(b) Taux de renouvellement



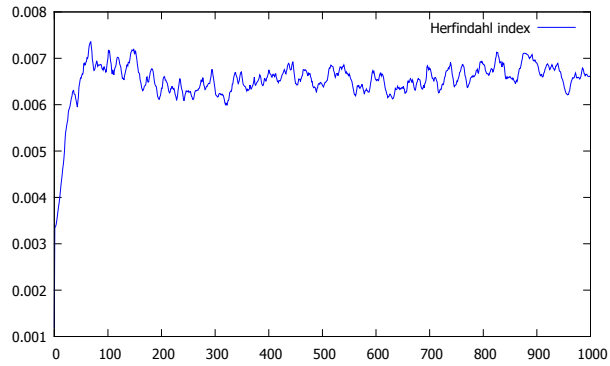
(c) Comparaison de taille d'entrants et de sortant par rapport aux firmes en place



(d) Taux de rendement de capital moyen pondéré

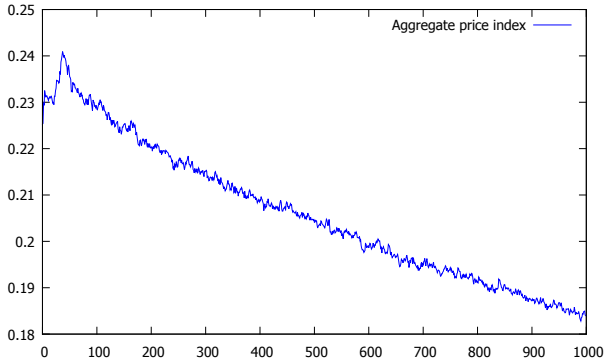


(e) Taux de marge moyenne

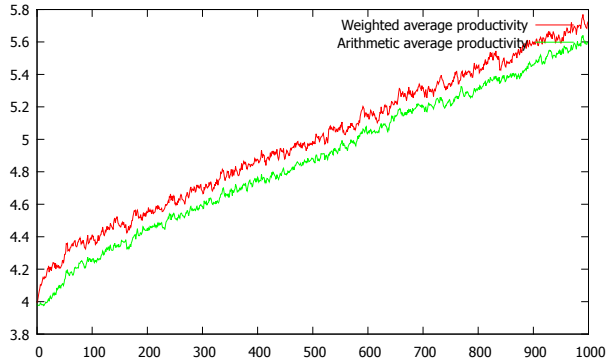


(f) Indice d'Herfindahl

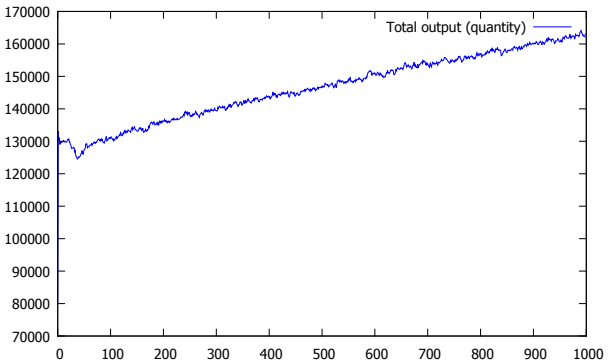
Simulations de référence - dynamique aggrégée



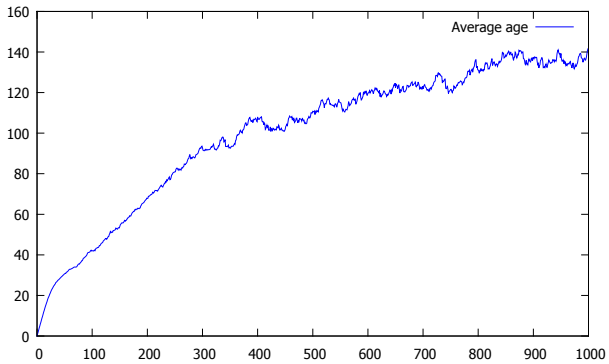
(g) Indice de prix agrégé



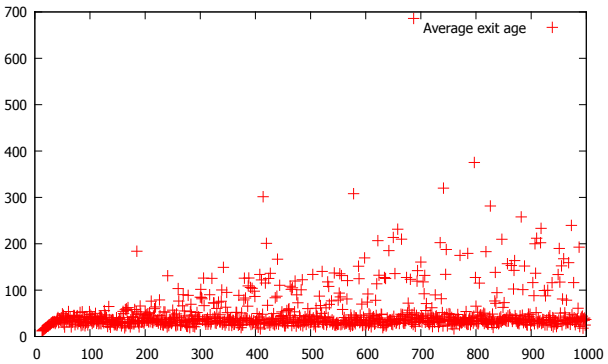
(h) Comparaison entre moyenne arithmétique et pondérée de productivité



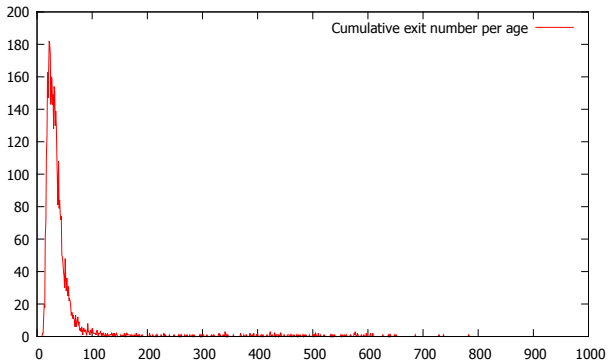
(i) Quantité de production agrégée



(j) Age moyen

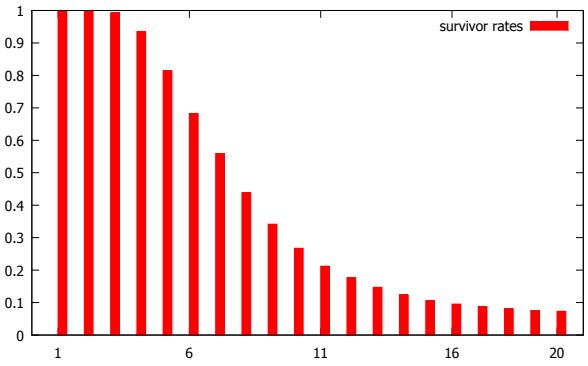


(k) Age de sortie moyen



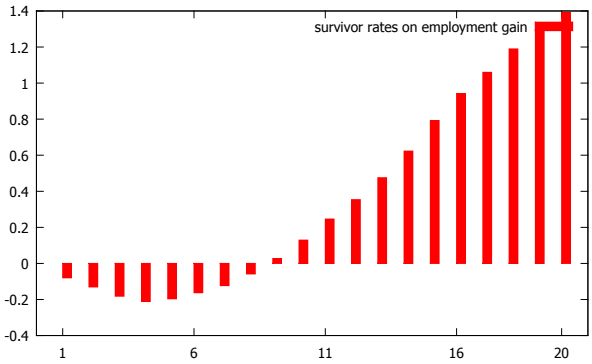
(l) Nombre de sortants par âge cumulé

Simulations de référence - dynamique aggrégée



(m) Taux de survie selon âge

(n) Taux de survie selon âge basé sur emploi



(o) Gain net d'emploi des firmes survivantes selon âge

Simulations de référence - taux de survie

croissance économique à long terme avec une progression de la productivité agrégée plus faible.

Comme ce que revendiquait la littérature précédente au sujet de la dynamique des firmes, il est nécessaire d'introduire des politiques économiques visant à faciliter l'accès aux sources de financement des jeunes et petites firmes. Néanmoins, la conclusion de cette thèse démontre que ces politiques doivent être en plus renforcées quand l'environnement macroéconomique est difficile. En parallèle, les mesures avec l'objective d'encourager l'investissement des firmes en R&D doivent aussi être inclinées à avantager les jeunes et petites firmes, dans le but de réduire le risque de faillite en raison de leur fragilité financière.

Suite aux travaux théoriques accomplis dans cette thèse, des études empiriques doivent être effectuées, afin de confirmer les résultats présentés dans la thèse, ou au contraire, de réfuter les arguments exposés.

En plus, la modélisation présente, ayant déjà prouvé sa stabilité et sa robustesse via un grand nombre de simulations, fournit davantage de possibilités à établir des systèmes économiques plus complexes, qui pourraient offrir des opportunités d'étudier des sujets de recherche variés.

Une des directions de recherche possibles à l'avenir est étudier les effets des fluctuations de différents éléments de l'environnement macroéconomique sur la dynamique des firmes. Le choc pétrolier des années soixante-dix ont laissé des souvenirs indélébiles à l'économie mondiale. Plusieurs études existent dans la littérature essayant d'analyser l'impact d'une hausse brutale du prix du pétrole sur l'économie. Par exemple, Blinder (1981) étudie l'arrangement monétaire des chocs d'offre en intégrant les anticipations rationnelles et indique que l'anticipation aux futurs chocs pétroliers a un impact important sur la dynamique économique. Dans un contexte de chocs pétroliers inattendus, il peut exister un compromis exploitable entre inflation et emploi, à l'opposé du cas avec des chocs pétroliers rationnellement anticipés où les résultats sont plus variables selon les particularités de modélisation.

Dans une étude plus récente, Dissou (2010) souligne le mécanisme de transmission par lequel une augmentation du prix du pétrole pourrait influencer l'économie. Il affirme que les chocs pétroliers pourraient avoir des effets positifs sur la croissance économique et améliorer l'allocation

des ressources qui conduisent à des inégalités dans les ajustements sectoriels. Au sujet du thème de cette thèse, il est intéressant d'analyser les effets qu'une hausse du prix des matières premières pourrait avoir sur la dynamique des firmes, en présence des contraintes financières et des fluctuations macroéconomiques.

Une autre extension potentille au cadre de recherche actuel est étudier la dynamique des firmes dans un contexte d'économie ouverte. De nombreux travaux de recherche focalisent sur ce sujet. Par exemple, Arkolakis (2010) analyse la dynamique des firmes dans une compétition de marché en introduisant une nouvelle théorie des coûts d'entrée, qui est compatible avec les faits stylisés au regard de la relation positive entre l'entrée des firmes et leur taille en présence d'un grand nombre d'exportateurs.

Dans une étude théorique, Atkeson et Burstein (2010) insistent sur les effets antagonistes de la dynamique des firmes par rapport à la libéralisation des échanges à long terme, et les effets compensateurs des changements dans les décisions des firmes concernant entrée, innovation, exportation et sortie sur la productivité et l'utilité agrégée. Avec la connaissance des études antérieures, incorporer les facteurs des échanges internationaux donne les possibilités d'étudier la dynamique des firmes à partir d'un nouvel angle de recherche, surtout en tenant compte des imperfections financières.

Par ailleurs, comme ce qui est mentionné précédemment, les modèles multi-agents permettent d'étudier de différents sujets avec l'existence de déséquilibre économique. Parmi les conclusions majeures dans l'économie moderne, une grande proportion est obtenue au travers des études théoriques avec une modélisation supposant l'existence d'équilibre dans tous les marchés. L'introduction de déséquilibre dans la modélisation donne des opportunités considérables à réviser ces conclusions d'un point de vue complètement nouveau.

Abstract

The thesis is composed of three research articles. Based on a common theoretical and modeling foundation, by means of computational simulation, these three essays study different subjects relating to firm dynamics under the impact of financial constraints and macroeconomic fluctuations. Respectively, the first article explores functioning of market selection mechanism, the second focuses on firms' Research and Development (R&D) investment patterns, the third analyzes effects of economic stimulus policies on firm dynamics.

The research results demonstrate that the combination of presence of financial constraints and macroeconomic fluctuations may have significant effects on firm dynamics in the context of competitive market. From different angles of analysis, the effects could reveal failure of market selection mechanism, market structure distortion which disfavors firms' R&D investment, and unequal repercussions of an economic stimulus on firms in recession, especially to the disadvantage of young and small ones.

Résumé

La thèse est composée de trois articles de recherche. Basés sur le même fondement théorique et de modélisation, au travers de simulation numérique, les trois essais étudient différents sujets liés à la dynamique des firmes sous l'impact des contraintes financières et des fluctuations macroéconomiques. Respectivement, le premier article explore le mécanisme de sélection de marché, le deuxième se focalise sur le mode d'investissement en Recherche et Développement (R&D) des firmes, et le troisième analyse les effets d'une politique budgétaire discrétionnaire de relance de l'activité sur la dynamique des firmes.

Les résultats de recherche montrent que la combinaison des contraintes financières et des fluctuations macroéconomiques peut exercer des effets significatifs sur la dynamique des firmes dans un contexte de compétition de marché. Sous différents angles d'analyse, ces effets peuvent révéler l'inefficacité du mécanisme de sélection de marché, la distorsion de structure de marché à la défaveur des investissements en R&D, et des retombées inégalitaires d'une éventuelle relance économique en période de récession, au désavantage des jeunes et petites firmes.